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ELECTRIC MELTING OF GLASS

By Y. R. CORNELIUS

Electric melting of glass has now passed from the hands of the inventors and developers into the hands of the operators. Its progress will largely depend upon how fast these operators can learn the new art and forget certain parts of the old.

Furnaces have been built recently, which are typically the same as built 40 to 50 years ago. It is also evident that many electric furnaces built years ago would have operated favorably, if the operators then had had the confidence and the knowledge of the operators of today, and had learned to avoid certain methods that strictly belong to the operation of combustion fired furnaces.

The matter hereunder is not a report on electric glass tank designing. It is a series of notes on electric glass melting in general, experiences in operation and tactics for the benefit of operators. As such it will naturally be controversial as no two operators are exactly in the same position. However, the sooner the operators begin to compare notes the sooner the new method will be fully mastered.

Progress in Europe

Electric melting has advanced more rapidly in Europe than in America. There are two reasons for this, namely, smaller tanks operating with cheaper labor, and the scarcity of oil and other fuels.

A tank as small as 5 tons per day is actually an operating unit over there, while we can hardly conceive operation below 15 tons average. Commercial operation of such small units makes possible a very reasonable development expense.

Scarcity of fuel advanced electric melting in several areas, almost to the point of total exclusion of other types of furnaces. Many oil fired tanks have been combined with electric heating, thereby gaining a production capacity of about 30 per cent per tank.

Presented before the Pacific Coast Regional Meeting of the American Ceramic Society.

Following is a report from Mr. A. E. Cornelius of Kungely, Sweden, on the number of electric furnaces in operation:

Sweden	Kungelv	1 — 13 tons
Sweden	Kungelv	1 — smaller experimental
Sweden	Emmaboda	1 — Window glass tank
Finland	Karhula	1 — 20 tons
Finland	Karhula	1 — Oil-Electric
Norway	Moss	1 — 45 tons
Norway	Moss	1 — 7 tons sodium Silicate
Norway	Moss	1 — Oil-Electric
Norway	Drammen	1 — Wire Glass
Switzerland	Kussnacht	1 — 5 tons
Switzerland	Kussnacht	1 — 13 tons

The St. Gobain Company reports more than 40 tanks either electric or oil-electric, some of which are included in the above tabulation.

Progress in America

The electric melting that is carried on in the United States is still very much in hiding as far as information is concerned. The installations are mostly commercial units built for the manufacturing of specific commodities.

At Niagara Falls there are two furnaces of my own design each producing 20 tons of sodium silicate glass per day. These have been in operation since 1932. Also of my design is one 25 ton per day bottle tank at the Northwestern Glass Company in Seattle, Washington.

The Northwestern Glass tank has operated since July 1945. It was originally designed for 750 kilowatts, which later was increased to 1500 kilowatts. The tank operated 17 months during its first campaign, which included one hot repair for changing of electrodes. Its second campaign is still on and was started in December of 1946.

For certain areas the interest is growing for outright electric tanks, particularly in colored glass operation to supplement oil fired white flint operation. The electric furnace has a definite edge over combustion furnaces because of higher efficiency on smaller tonnage and better performance on colored glass.

The electric furnace building at Northwestern Glass Co., Seattle, Wash.

The oil-electric is gaining interest as a means of increasing capacity in old plants where space is limited. Cost of making such installation is also relatively low.

Progress in this country will gain as the glass industry accepts more of the benefits of electric melting, and is able to convert these benefits into dollars and cents. This is actually the experience of the electro-steel furnace. The steel industry was reluctant to adopt the electro-steel furnace, but it eventually learned that the extra cost of electric power was compensated for in other benefits.

Types of Furnaces

While the furnace designers started widely apart, their designs are becoming more similar. This is quite natural as later furnaces are based upon performances and inspection of earlier ones.

The European developments may be ahead of us in number of units operating, and have made certain claims to superior quality. However, in respect to power consumption there is a remarkable difference. Various reports from Sweden, Finland, Norway and Switzerland give the power consumption consistently around 1650 KWH per 2000# of glass, while our average is about 950 KWH per 2000# of glass.

No information is available, whether power has been sacrificed for glass quality or for tank cooling. In my opinion neither is necessary as good quality glass has been produced at Northwestern Glass Company continuously for several months using only 950 KWH per ton. Furnaces in Europe are predominently operating by feeding batch in one end to a clear glass surface. It is then easy to loose 700 KWH or 2,000,000 B.T.U. We have operated similarly but found no improvement in quality, rather to the contrary.

Different electrode arrangements are used but even in this respect it may be safely stated, that within reason they all work, subject to time for the operator to find his bearings on each particular arrangement. In our case, it was desired to find an electrode arrangement, which if necessary could be replaced without interfering with production.

Molybdenum electrodes are being used in certain instances in this country. They have the advantage of high melting point. They are subject to oxidation but its oxide is colorless in glass. Considering the carbon loss of 0.5 oz. per ton glass, it seems wholly unnecessary to resort to expensive molybdenum except in cases of some special glasses.

Cornelius Electric Glass Furnace

A 30-tons per day electric glass furnace is shown in drawing 17-201.

The furnace consists of three chambers divided from each other by two bridge walls. The glass passes from one chamber to the next through submerged throats in each bridge wall.

The first bridge wall is not really necessary but its advantage is explained later in this paper.

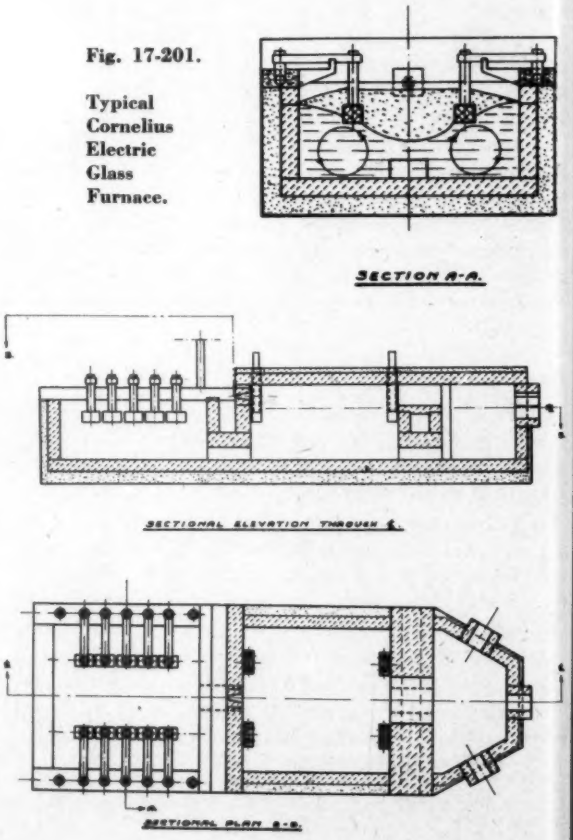
All electrodes in the furnace except those for the nose end are suspended from above. The electrodes in the melting section penetrates a batch blanket covering the entire surface of the melt. None of the electrodes in the furnace are cooled artificially. They are all made of carbon except the nose and electrodes, which are made of iron. Some carbon electrodes have operated for 9 months, and so far the nose end iron electrodes have operated for 27 months. The electrodes in the clearing room penetrates its crown, and are protected from attack from the furnace atmosphere.

The electrodes in the melting section are spaced half way between the furnace center line and the longitudinal side walls as shown, in Section A-A. The raw material batch gradually sinks beneath the plan of the opposing

(*Continued on page* 96)

Fig. 17-201.

Typical Cornelius Electric Glass Furnace.



A SCALE OF ACIDITY AND BASICITY IN GLASS

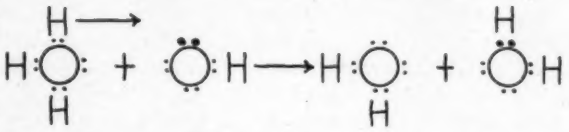
By KUAN-HAN SUN

In a paper on "Lewis Theory Applied to Glass," Sun and Silverman[1] have clarified the concept of acid and base in glass technology from modern viewpoint. They also pointed out that glass formers, such as B_2O_3, SiO_2, GeO_2, P_2O_5, BeF_2, GeS_2, etc., are acids because of the electron-accepting nature of the cations in these oxides; and modifiers, such as CaO, Na_2O, NaF, K_2S, etc., are bases, because of the electron-donating nature of O^{--} which are loosely bonded in these oxides. Intermediates, such as TiO_2, Al_2O_3, BeO, AlF_3, etc., are grouped as amphoterics. Actually, the classification of acids, bases, and amphoterics is arbitrary. It depends on the other reactants present in a neutralization process.

Lewis' theory, beautiful, comprehensive and fundamentally sound as it has been, is only a qualitative theory. Chemists are yet unable to arrange acids and bases in a quantitative series according to their affinities for electron-pairs. It was regrettable that glass chemists were not the first to develop the modern theory of acid and base, particularly since they were among the first who should have noticed the discrepancy and inconsistency of the old theory. The present paper intends to offer, for the first time, a semi-quantitative scale of the relative strength of acids and bases in glass or in non-aqueous solution of oxides in vitreous state.

Before the presentation of the scale, it would be advisable to review briefly the qualitative concept of the modern theory of acid and base as applied to glass.

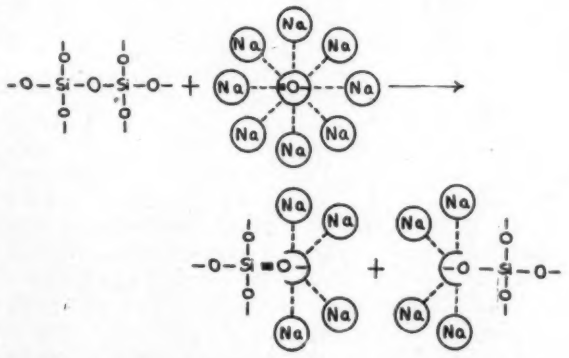
Glass chemists and technologists for years have applied the terms "acidic" and "basic" components to glass making substances, even though they are fully aware of the fact there are no hydrogen or hydroxyl ions in glass, using for the moment the terms of the old concepts of acids and bases. In terms of the newer Brönsted proton-transfer theory, when an "acidic" component, such as SiO_2, is fused together with a "basic" component, such as Na_2O, there are no proton transfers. Glass reaction cannot be interpreted by the classical theory or the Brönsted theory of acids and bases, although glass chemists and technologists still use the terms "acids" and "bases" in discussing batch or glass ingredients. The Lewis theory, which includes all known reactions between acids and bases, is rather simple and easy to learn if all the old concepts of acids and bases are discarded. According to this theory, the difference between an acid and a base is not due to the presence of particular atoms or ions but to their differences in electron structure which influences their behavior in the sharing of electrons. In a way it is like oxidation-reduction when this is interpreted through electron rather than oxygen relationships. An acid, accordingly, is an atom, ion, radical, molecule, or molecular group which can accept an electron pair to form a coordinate bond. A base is an atom, ion, radical, molecule, or molecular group which can donate an electron pair to form a coordinate bond. Neutralization is the formation of a covalent bond through coordination by an acid and a base. In oxidation-reduction, an oxidizing agent accepts electrons and a reducing agent donates electrons. It also involves the transfer of electrons. The chief difference between neutralization and oxidation-reduction reactions is that the former involves the sharing of electron-pairs to form covalent or coordinate bonds and the latter usually involves the transfer of valence electrons. Reaction (1) illustrates neutralization.



H^+ in the Hydronium ion as electron-pair acceptor | $O^=$ in the hydroxyl ion as electron-pair donor | Formation of the new water molecules

In oxidation and reduction, the relative magnitude of electron potentials decides whether a substance should be called an oxidizing or a reducing agent with reference to another substance. The same idea should apply to acids and bases and it is the purpose of this paper to provide such a scale. It is obvious that whether a substance should be called an acid or a base is not determined by its chemical formula but by its tendency to be an electron-pair acceptor or donor.

In glass-formers, there are usually continuous networks which are linked by the strong bonds between the positive atoms of Si, B, P, Ge, etc., and the negative atoms of O, F, Cl, S, etc. The positive atoms are usually electrophilic, and if there is an excess of loosely bonded negative atoms, present or introduced, a rearrangement of charged atoms, or ions, would be expected or a reaction which results in sharing electrons of these positive atoms with the excess negative atoms. The excess negative atoms, or ions, are usually provided by the bases introduced in which the bonding between the negative oxygen atoms and the positive atoms are considerably weaker. This may be shown schematically for a typical glass reaction between SiO_2 and Na_2O as in reaction (2):



Note the transfer of the particular single bond (—) from sodiums to silicon.

In above reaction, we assume that a single bond, —, represents a pair of sharing electrons and a dotted bond, . . . , an undefined weak electronic linkage between Na^+ and O^{--} which is much weaker than a pair of elec-

trons. Crystalline Na_2O is known to have a CaF_2 type of structure, in which each sodium is surrounded by four oxygens and each oxygen by eight sodiums. The structure of liquid Na_2O is unknown and is dependent on temperature. In glass it is known that each sodium is surrounded by about six oxygen. For our illustration, we simply assume a random structure but otherwise similar to that of crystalline form. Apparently it is impossible to draw significant electronic linkage for such a structure. For that reason a circle is drawn to represent the distribution of electrons around the atom. In reaction (2) only one out of four (or six) weak bonds between Na and four (or six) other oxygens is shown. A new covalent bond, as indicated by the heavy line, is formed during the reaction. It is the formation of this covalent bonding, or more generally stronger linkage, of the oxygen from Na_2O (or base) that constitutes the process of neutralization. The electron donor, O from Na_2O, which forms only weak bondings with Na, $Na^{-}O$, is the center of reaction. It is undoubtedly the base. The electron acceptor, Si from SiO_2, which forms strong bondings with O, Si—O, is the acid of the reaction. It is apparent then, the weaker the bonding between an element, M, and oxygen, O, the stronger the oxide will react as a base, or conversely, the stronger the bonding, the stronger it will be as an acid. A scale of acid and base can be easily obtained if the relative bond strength of various M-O bonds are known in glass. It is important to point out at this point that the terms, "bond," and "bonding," used so often in this paper, should not be interpreted too literally. They are used merely for convenience; actually they refer to the probability of the localized concentration of electron clouds in certain definite directions between atoms.

The estimation of bond strength in glass has been done by comparing the ionic potentials of the cations. For example, it has been universally used in all works of Weyl.[2] The ionic potential is defined as (ze/r) where z is the atomic number or the nuclear charge, e, the electronic charge and r, the ionic radius of the cation in consideration. It is derived from a simple (but incorrect for crystals, liquids or glasses) formula, eq. (3), of binding energy of a substance containing two oppositely charged atoms.

$$E = \frac{z_1 z_2 e^2}{(r_1 + r_2)} \qquad (3)$$

where z_1 and z_2 are the charges of two ions, r_1 and r_2 the radii, and E the binding energy. Equation (3) holds only when the two ions are in free space without any other neighboring ions of the same or different kinds; and the "ions" are true ions, that is, the linkage is electronic rather than covalent in nature. These are not true in case of closely packed and not purely ionically-linked substances, such as ordinary crystals, glasses, or liquids. For the latter substances, the calculation of binding energy is much more complicated than that expressed in equation (3). It involves constants such as Born repulsion coefficient, Madelung constant, and others.[3] The Madelung constant is a function of the geometrical structure of the substance. Since the exact geometrical structure of glass is unknown, it is impossible to evaluate the binding energy, and consequently the bond strength of various M-O bonds in glass. At any event, the use of the so-called ionic potentials to estimate the bond strength is not justified.

An alternative approach to the solution is the use of thermal data involved in the formation of glass, since these are measured experimentally and automatically take care of the geometric factors and charge distributions. Such an approximation has been caried out by Sun,[4] who estimated the bond strength from the dissociation energy of the component MO_x in glass and the oxygen coordination of M. The list of bond strength thus obtained agrees well with the behaving of various compo-

(*Continued on page 98*)

TABLE I

SCALE OF ACIDITY AND BASICITY IN GLASS

	M_mO_n	Coordination No. of M Adopted	The Arbitrary Scale (M-O Bond Strength)
		GLASSFORMERS	
	B_2O_3	3	119
	B_2O_3*	3, 4	113
	SiO_2	4	106
	GeO_2	4	108
	P_2O_5	4	88–111
	V_2O_5	4	90–112
	Al_2O_3	4	79–101
	B_2O_3	4	89
	As_2O_5	4	70–87
	Sb_2O_5	4	68–85
	ZrO_2	6	81
		INTERMEDIATES	
	TiO_2	6	73
	Al_2O_3	6	53–67
	ThO_2	8	64
	BeO	4	63
	ZrO_2	8	61
		MODIFIERS	
ACID → BASE	Sc_2O_3	6	60
	La_2O_3	7	58
	Y_2O_3	8	50
	SnO_2	6	46
	Ga_2O_3	6	45
	In_2O_3	6	43
	ThO_2	12	43
	PbO	6	39
	MgO	6	37
	Li_2O	4	36
	PbO	4	36
	ZnO	4	36
	CaO	8	32
	SrO	8	32
	BaO	8	33
	CdO	4	30
	Na_2O	6	20
	CdO	6	20
	K_2O	9	13
	Rb_2O	10	12
	HgO	6	11
	Cs_2O	12	10

*In ordinary commercial borosilicate in which there are abundant of oxygen for all boron to change to coordination of 4. Unpublished investigation by the author, however, reveals that only about 20 per cent of the total boron atoms take 4-fold coordination, the rest remain in a coordination number of 3.

CONVECTION CURRENTS IN A GLASS TANK

By IVAN PEYCHÈS, Sc.D.
Director of Research in the Glass Factories of the *Compagnie de Saint-Gobain*

TRANSLATED FROM THE BULLETIN DE L'INSTITUT DU VERRE (PARIS) FOR JUNE, 1947

By LOIS SUTTON and S. R. SCHOLES

PART II

Experimental Results and Their Interpretation

A.—Components of the principal current.

a. *The current of the pull.* This is the current observed *in the absence of all convection,* from the single fact of flow arising from removal of the glass. It is a *theoretical* current whose value brings in a hypothesis: the depth concerned. One cannot admit that the glass advances on a front, in the whole tank, under the influence of pull alone, after the manner of a piston. The glass being more fluid on the surface, the contribution of the surface will certainly be preponderant. The interest in this idea of the pull current resides in the fact that in very hard-driven furnaces, it is by no means negligible in comparison with convection currents, upon which, in all circumstances, it is superposed. In what follows, we shall denote by V_o the speed of the pull current, without further explanation.

b. *Point-source* (*Point of origin*). Molten glass, like all pure liquids, has a *positive* coefficient of expansion; its specific volume increases with the temperature. This coefficient is of the order of 10^{-4} (per °C.). Between two points in the bath differing by 100°, the density differs by 1%. If the heating of the bath were perfectly uniform over all its surface, and if no external cooling intervened, there would be no convection currents, because the liquid would become established in laminae in stable equilibrium, the hotter ones in the upper portion. But, in fact, losses through the walls exist. These latter, if constructed of alumina-silica refractories 30 cm. (12 in.) thick, lose, each hour, 4,000 kilocalories per square meter (1480 B.T.U./ft.²). This loss rises to 10,000 K-Cal./in². (3,700 B.T.U./ft.²) for walls of cast refractory, and rises still more if there is wind-cooling.

In a wide tank, even uniformly heated, an ample twisting movement becomes established, because of the cooling of the glass toward the walls: the glass cools on the surface, from the middle—the part most protected from the influence of the walls—toward the borders, becomes heavier, reaches the bottom, gathers together in the central zone, repelling the glass which is already there toward the surface, where it becomes heated again and recommences the same cycle. This point of resurgence is known under the name of "point-source of Gelhoff" (Quellpunkt) (Spring-point) (Figure 9-a). It is naturally found at the trough of the isothermal curves which could be experimentally surveyed on the tank.

In a long tank, which by construction is heated only in one part because the glass must be cooler for working, the loss of heat at the walls of the unheated portion likewise causes the hot glass to enter a great cyclic movement superposed upon the preceding movement. The ensemble is schematically represented in Figure 9-b. It goes without saying that the theoretical point concerns a rather large zone. The operator can, within certain limits, displace the point-source, planning for it by regulating the burners. In long furnaces with cross-firing, the attempt is generally to locate the point-source ("hot-spot") in line with or near the next-to-the-last burner port. At this point, the melting *proper* ought to be complete. The physical reason will appear in what follows.

c. *Thermal barrage formed by point-source.* The extreme cooling at the charging (dog-house) end, where the raw batch enters, summons hot glass toward the head of the furnace. The latter, issuing from the hot source, runs counter to the pull. If the pull is light, the lumps of batch may return to the doghouse, and the teaser must push them along.

In most instances, there is only an effect of delay, which is particularly interesting to study. If we designate positively the speeds of the furnace charge directed toward the working end, and negatively, speeds in the reverse direction, we have to superpose the curve A, due to the pull (constant speed V_o), and the curve B, due to

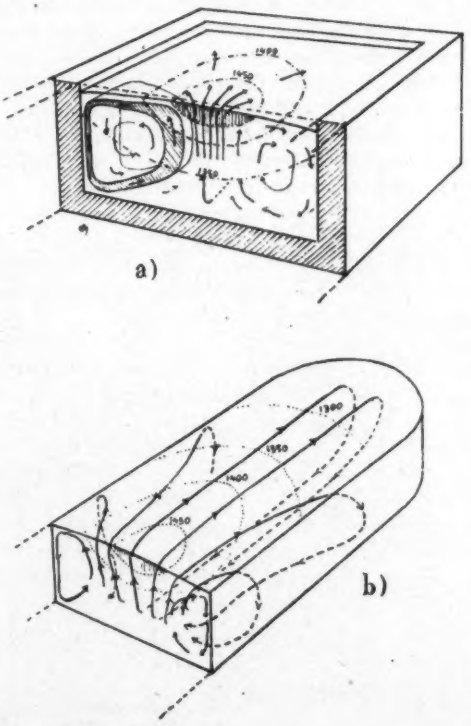


Fig. 9. The "point source."

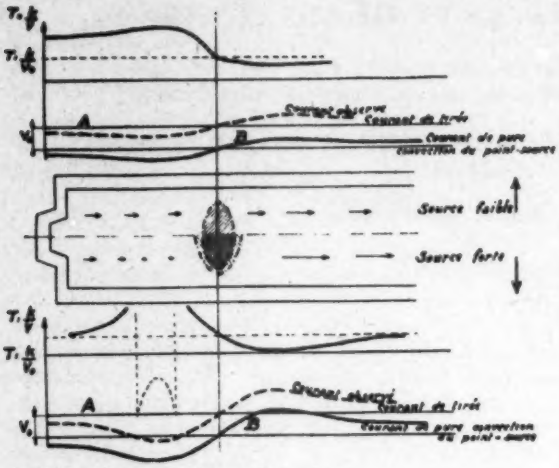


Fig. 10. Effect of "thermal barrier."

convection setting out from the hot source (Figure 10). The resulting curve is a dotted line. It may have several forms in the region situated between charging and the point source: 1) It may not cut the x-axis; there is only retardation. 2) It cuts the x-axis; there is interruption of flow. 3) The batch returns to the doghouse.

We designate these effects "thermal barrage" due to the hot source. The time of sojourn in a given zone is inversely proportional to the speed of travel in this zone. For maximum benefit of the hotter zones, it is of interest to have the batch traverse them as slowly as possible while being able at least to reach these zones. The optimum effect of the thermal barrage ought then to be contained between too small a value of the hot source, which does not sufficiently hold back the batch piles, and too high a value, which stops their forward movement.

d. *Roller effect.* This name is reserved more particularly for the large convection current moving from the hot source toward the cold zone established by the part where the "baking" of the glass is accomplished, and enclosing itself in the depths. These zones may communicate fully or be separated by barriers or throats without changing the general picture of the phenomena. Their particular influence will be studied later.

Between these two points, the temperature drop is considerable: 300° for working by hand or by feeder, or again, for drawing by the Pittsburgh process; 450° for drawing by the Fourcault process, for example; convective phenomena acquire much importance.

Moreover, it is not necessary to represent this current as a bodily displacement of a certain mass of glass. Continuously, throughout the length of its longitudinal course, the glass at the borders of the stream cools and abandons the general flow, to sink and rejoin, by a shorter path, the slow reflux of the deep glass. It is only in the median plane of the furnace that we discover, in all its purity, the *surface current* or *direct current,* or bottom flow, the *return* current. Between the two is found the neutral line where the phenomena of stirring up are particularly active.

e. *Surface current.* It is revealed by floats. In long furnaces, we have stated that it may reach a speed of ten meters per hour. It is more or less perturbed on the surface by the action of the flames, which call forth alternate drifts as a consequence of reversals. Toward the sides of this principal current, one may observe stray flows approaching the side walls and being swallowed there (influence of the transverse component). The floats tend to cling to the walls.

Figure 11 represents isochronous curves of three floats. One will observe: (1) the retarding effect as the hot source is approached; (2) increase of speed past the hot source; (3) one of the floats clinging to the wall; (4) stagnation of other floats in the zone preceding the dam or bridge wall (barrage).

The speed of the surface current diminishes quickly in depth. It has been remarked that Oppermann found, by means of his balances, that the direct current involves only the upper one-third of the bath. Evidently it involved a particular case. We have observed that in the very hot zones, the direct current is flattened upon the surface and involves only one-fourth of the depth of the bath.

In the working zone, the speed is considerably reduced, but the thickness is greater. Schneekloth[20] has found no measurable difference in speed between a float immersed to 3 cm. and a Novaky plunger reaching a depth of 26 cm. Models indicate, toward the unheated end, a determined plunging of the surface current,* and the erosion lines well confirm this point of view (see Figure 12) which permits understanding of Schneekloth's observations.

f. *Return current.* All glassmakers have had occasion to observe the reality of this return current. The cold and viscous glass may drag, from the working chamber toward the melting end, dense objects that have accidentally fallen into the tank, such as glassworker's pipes or dense brick. This reality is again emphasized by the direction of erosion tracks on the blocks and on the bottom. This current flowing back toward the hot zones heats up little by little and tends to ascend. Its general thickness increases, moreover, in consequence of that which we have said earlier, since it gathers the currents which have taken the shorter path by the lateral walls. Direct exploration, at the depth involved, is difficult. Mean speeds of the order of a meter per hour have been measured.

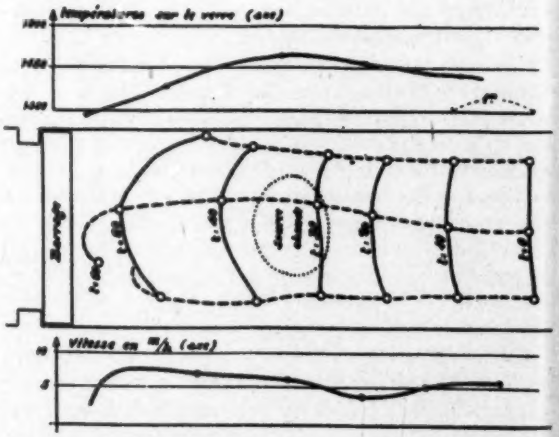


Fig. 11. Trajectory of floats.
Source change = hot source.
Vitesse en m/h (axe) = speed in meters per hour, on the axis.

20. W. Schneekloth, *Glastech. Ber.*, April, 1939, pp. 99-104.
*See Plate I.

Fig. 12. Tracks of currents.

g. *Neutral line.* This is really the zone where the direction of the current reverses. The readjustment does not occur following an ideal line. The ill-defined laminae of glass work into each other. The neutral line thus appears as a zone of active exchanges between the direct current, rich in fresh glass, and the return current, rich in "settled" (plain) glass. This is a strong factor in homogenization. In Figure 12 may be observed this zone of small eddies, at the meeting of glass which has leached the upper part of the wall and is ready for its descent, and glass carried by the return current. It is this quantity of fresh glass brought from the surface, and not yet cooled, which explains how the compensation of losses from the bottom of the tank is not accompanied by a new sluggishness of the return current, which, in that case, could only flow more and more flatly toward the hot zone. This would be a result contradicting observations of the erosion tracks. (These tracks are easily visible at the border of the bottom shown in the lower part of Figure 12.)

B.—*Reaction of incidental features of the tank upon the principal current.*

Certain features of the tank make it far different from the new, polished tank that we have considered thus far. They are: joints; floaters; projecting walls and constrictions; throats, openings of small cross-section, separating chambers one from another.

a. *Influence of joints.* A joint constitutes naturally a preferential line for erosion. Glass which has been in contact with the alumina-silica refractory is charged with alumina and has become very viscous. It would form a protective coating, if it were not, very slowly but continuously, dragged away by the currents. One should give attention to the fact that this "washing" would be favored by a turbulent condition; that is to say, more often when the joint is perpendicular to the direction of the current. *A priori,* it is therefore the joint perpendicular to the direction of the current which wears the most.

Now, against the walls, and above all directly opposite the hot spot, the currents descend almost vertically (see further on). It is then the horizontal joint which wears away most. Jebsen-Marwedel has presented[21] some beautiful photographs of striae in glass at a joint, which are reproduced schematically in Figure 13, and which indicate how the glass works in these cavities.

The horizontal joint between two courses of blocks usually widens very rapidly. It is a line of extreme cooling for the glass, the more so because, for reasons of security, the worn joint is generally wind-cooled. It is a well-indicated zone, because there the current tends to carry the glass from the wall straight downward. Also, the neutral line has a tendency to remain there, and there the small turbulences arising from the meeting of the direct and return currents continue to *gnaw* at the wall, dangerously. Figure 14 shows this horizontal joint separated by two currents. It may be compared with Figure 12, which shows this same region, but without the horizontal joint.

b. *Influence of a barrier.** It has been believed for a long time that the cooling effect of a barrier was due to the shadow which protected the glass, under and behind the barrier, from the radiation from the crown and from the flame. We have shown that the effect is exactly the same in furnaces electrically heated by the resistance of the glass itself. In all cases and whatever be the depth of immersion of the barrier, we have established that there is found on the surface behind the barrier an isotherm which depends for its position upon the depth of the barrier. We shall take up this question farther on when we speak of double barriers. For the moment, this simple statement will suffice for interpretation of the movements of the glass under the barrier.

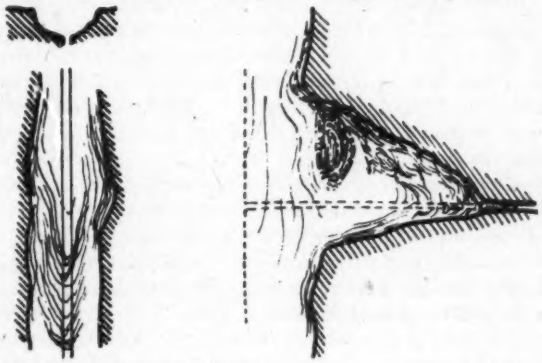


Fig. 13. Currents at joints.

When we study the displacement of floats, we note that the speed diminishes rapidly a little in advance of the barrier, and that the float can even stop in a zone which seems to be dead quiet. It is the skimming effect of the

Fig. 14. Tracks of currents; influence of a horizontal joint.

21. *Glastech. Ber.* 5., 1932, p. 257.

*It should be noted at this time that a large part of what we are about to say applies to throats.

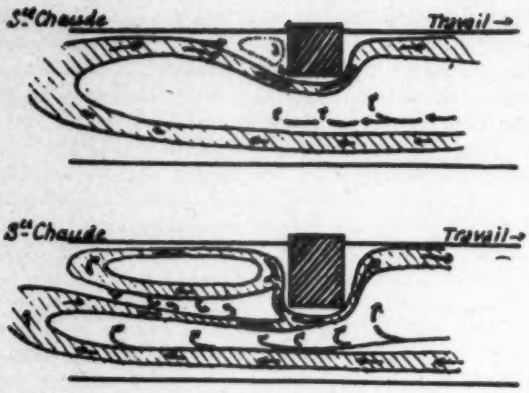
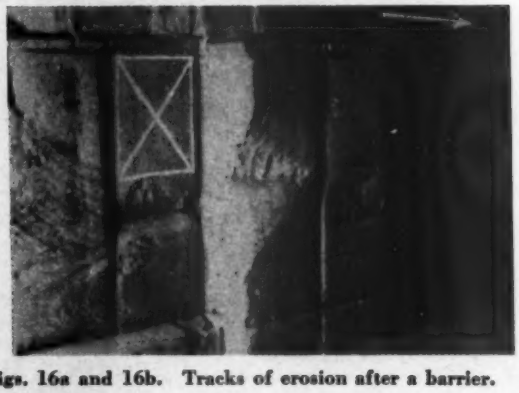


Fig. 15. Different regimes under a barrier.
S^te Chaude = hot source.
Travail = working end.

barrier. But that signifies that the surface glass begins to go down a little in advance of the barrier as it arrives at a line which we shall call the "sinking front," and which is situated as much farther in front of the barrier, accordingly as the latter is more deeply sunken or as the glass is more viscous.

What becomes of this glass which sinks in front of the barrier? It is here that observation offers the most contradictions. Certain authors suppose that it returns in an underlying current directly to the hot source; the current under the barrier provides another cyclical movement involving only the deeper glass. Others think that the sinking current resurges in its entirety beyond the barrier. The wiser ones admit the superposition of the two effects with a branch of the surface current beyond the barrier. We shall give in the latter part of this work



Figs. 16a and 16b. Tracks of erosion after a barrier.

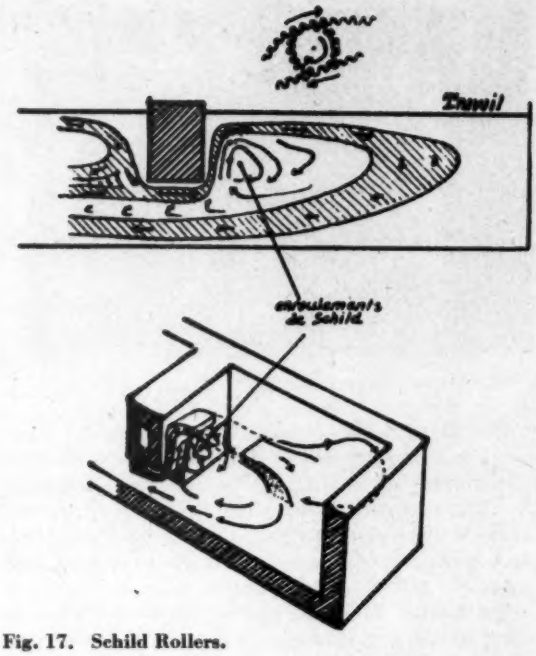


Fig. 17. Schild Rollers.

a rational explanation of these apparent contradictions. It is the case of the mixture of streams which we shall consider as the general case.

Under the barrier, a current forms having a triple origin and constituted by: 1) the branch of an upstream surface current engaged in a cycle pressing upon the barrier; 2) the direct current of the cycle involving the two compartments separated by the barrier, a cycle which, going upstream, is underneath the preceding cycle; 3) certain "reversals" of the general return current.

If the barrier is slightly or moderately sunken, the local upper cycle is not formed. The general cycle of (2) occupies all the upper part of the bath upstream and passes under the barrier. Figure 15 shows these different cases. Behind the barrier the "shift" is very rapid as shown in the photograph *16-a*. The following photograph, *16-b*, shows from left to right, in the upper part, the sinking of the glass, below, the turning up of the return current; then, the shift against the sole of the barrier and the beginning of the exchange zone which we shall find again in the lower part of Figure 12.

c. *Schild Rollers.* When glass which is still very hot, like that which constitutes the shift behind a barrier or a throat, penetrates into a zone of relatively cooler glass, there is a strong disturbance of the isothermal lines (see the plates in the third part of this study). The return current of cold and viscous glass cannot sustain the abrupt changes in the direction of the direct current of hot and fluid glass; there is a triangular zone which, theoretically, ought not to participate either in the direct current or in the return current; but in fact the glass of this zone is dragged along after the manner of a train of gears in a stable movement of rotation upon itself (Figure 17). It is this movement which has been designated under the name of the Schild Roller[22] ("Waltzer" "Roller"). But whenever cold glass is returned upstream by the entraining effect of another current, it can enter into a fixed circu

(*Continued on page* 104)

22. Schild, A., *Glastechn. Ber.*, 11, 1933, pp. 305-314.

STATISTICAL CONTROL

By DR. J. H. TOULOUSE, Chief Engineer

Quality and Specifications Department, Owens-Illinois Glass Company, Toledo, Ohio

Why do two supposedly identical molds, made on the same machinery, produce bottles of different dimensions? Why do consecutive bottles from the same mold differ? Why do two analysts, making a grain-size check of samples from the same car of sand, differ in their reports? Why do two ceramic bodies from the same materials take the same fire differently? (Or was it the same fire?) Why do sellers and buyers argue over tolerances?

The alibi answer is that "ceramics" is a "different" industry—we have to become accustomed to the way ceramics vary, as compared to other industries—all of which is no answer at all, and certainly far from the truth. The real answer is that variation is the rule of all things: ceramics, steel, natural woods, speed of light, gravitation; in fact, of all things both made by man and by nature. But, how much we understand the variability of these things, and how well we learn to handle these variations is the problem of handling the *laws* of variation, or probability, or chance.

During the war a great deal of advance was made in what has become known as the statistical method of quality control. It involves the practical application of the laws of chance, or probability. These are often called the "laws of small numbers" since with small numbers, as in a small sample, the effect of each unit is great. Many industries used an application called the *control chart* as a means of controlling quality of production. Many millions of dollars were saved by war time applications.

Fortunately, the mathematics of the applications are simple, and much application can be made with no more complicated mathematics than adding, subtracting, taking square roots, and determining averages. It is quite possible to "dig" the method out of some of the texts which I will mention later, although the intensive ten-day courses that are being given in various places are of far greater value. From this simple start one can go as far as one likes in application to specific problems.

There is no time, in a short exposition, to go into the fundamentals of the statistical or probability methods. The only hope of success under the circumstances is that enough can be shown to excite a curiosity that will enable you to discover for yourself the things that can be applied. The whole matter of the statistical method can be boiled down to one thought: sampling, and what to do about it.

A great many of our test methods, whether on bottles, enamels, brick, porcelains, insulations, and the like, are destructive. The sample is destroyed in the test. If 100% testing were used, there would be no product to sell. So, we must take a sample—a small portion representative of the whole group or lot. We must infer the quality of the large lot from the test results on the sample. But—how small a group—how is it representative? And, if we are interested in finding the weakest or the strongest, or the smallest, or the largest units possessing some measurement, what are our chances of finding it, or them?

Briefly, if a large sample is taken, and the variable in question carefully measured, it is common to many things that these measurements fall into a pattern. The pattern is usually one where many units have almost identical measurements, with a few more just a little smaller, and a few just a little larger in that measurement, with still fewer exhibiting measurements a little further removed from the average of the bulk of the measurements, and finally, a very few considerably smaller or larger. If the data from all the measurements were expressed as a frequency curve or histogram, it would rise slowly from the baseline of zero frequency, then move more abruptly to a curving peak, and down to zero in the same fashion. The curve may not be exactly symmetrical, or in the form of what we call the "normal curve," but, in general, repeated groups of tests would give similar curves. This pattern of test results is the key to the statistical method, as it ties in with the pattern of frequency distribution from various probability functions. *The basis for the application of the statistical method to the ceramic, or to any other industry, is the development of a knowledge of the typical frequency distributions of the various measurements involved and what the relation is to a small portion as a sample.* The laws of chance come in when chance dictates which units from the whole group turn up in the sample.

If we are lucky, the frequency distributions of the measurement will approach the form of the "normal curve" for which elaborate mathematical treatment has been worked out. But we do not have to be that lucky to use the method. If the pattern of measurement, after several hundred specimens have been studied, is a *pattern*, a useful tool has been found.

The next step is one of sampling. Here, there is room for all the argument in the world—until the arguers find that they are talking on the same side of the question and do not realize it. Both arguers' judgment may be based on one or a half dozen units in a sample. In so small a number, if one happened to observe one more sample from one side of the frequency distribution than the other side, while his fellow had the reverse experience, they would be lost in this "fog of variation." Such variation of sampling is not only possible, but probable. The same man, taking two sets of samples, would have the same experience.

Study of statistical methods would tell us that since the whole group or lot had a certain pattern of variation, then the averages of the measurement of small samples will show similar *but narrower* variations. The larger the sample, the smaller the variation. In general, in order to reduce the variation of the average by half, one must quadruple the size of the sample. Even if the pattern of frequency in the whole lot is not strictly a "nor-

Presented before the West Coast Regional Meeting of the American Ceramic Society.

mal" curve, the pattern of the averages does approach the "normal" pattern.

Now, taking larger samples does not reduce the variation of the group—it simply reduces the variation of the average value of the measurement of some quality of the units taken in the sample. The only function of the larger sample is to secure a less variable estimate of some quality, usually to decide whether two lots, by reason of the inspection results, are reasonably from the same group, or of the same quality, or not reasonably so, *on the basis of the inspection results.* Since sampling costs money, one important decision is whether the sample size is worth the information it gives.

The question of sample size, particularly economic sample size, brings up another question: what test is being applied? Two kinds of tests, or measurements, are recognized. One is a sampling by "attributes," the other by "variables."

Testing by attributes is testing to some yes-no basis. Go-no-go gauges are examples, where a piece-part either takes the gauge, or does not. To a great extent this is modified to determine a division into these groupings—over maximum tolerance, between tolerances, or under minimum tolerances. Many such tests can be applied, as to dimensions, weights, capacities, grain sizes, and the like. Perhaps the majority of tests are of this kind. Many, in particular, are of the non-destructive kind, many are easy to apply, and in general, less skill is needed.

Two serious faults can be found with this method. One is that the operator does not know *how close* to the borderline of tolerances the measurement the particular piece falls. If close to borderline, a slight change may produce off-specification product. A widely scattered frequency of measurement values will be more apt to cause off-specification units than a narrow field of values, but no indication of it is given by the attribute method.

The second fault is that *large* samples are required to give useful figures. In order to determine whether no more than one per cent of off-specification units exists, something *over* one hundred units must be examined, and so on.

On the other hand, the test may be economical because it can be performed quickly, with the only burden, the handling of many pieces. High skill on the part of the inspectors is not needed.

Tests by "variables" means that careful measurement is made on each piece, to the most appropriate degree possible, whether in inches, pounds, degrees, or the like, or divisions of these units. Instead of determining whether the capacity of a bottle is "somewhere" between 31½ and 32½ fluid ounces, measurement may be made and recorded to the nearest $\frac{1}{100}$ of an ounce. From the individual or the average results of five, or ten, or twenty-five units in the sample, one determines a lot more exactly whether the capacity is running near the ideal, or dangerously close to the specification limits. Five to twenty-five units measured by "variables" may give as much useful information as one hundred to five hundred units measured by "attributes." But the cost of measurement is greater, and the skill required is higher. The choice may be on the reason of economics, adaptability of the test, availability of skill, or speed of operation.

Whatever the method, the measurements, particularly the averages, probably fall into the statistical pattern already mentioned. Therefore, a study of the statistical method is of primary importance to all our sampling.

Of great importance is the problem of sufficient numbers of units in the sample. We are prone to take too few in many cases, and too many in others. The answer to either can lie in a study of the measurements, and of their frequency distribution, as well as a decision as to the attribute or the variable method of measurements.

Agreements between buyer and seller, since they involve sampling as a usual procedure, should be made on the basis of the probability implications of the sample size agreed upon. Too few units in the sample breed *arguments over natural variations* inherent in the number chosen. Paradoxically, they lead to the acceptance of bad units, and to the rejection of good units. The inevitable result is to "tighten up the specifications," when what is needed is a sound choice of the size of the sample, and an understanding of the question of statistical variation. So, in this field, knowledge of the statistical method is needed.

As an illustration, consider an actual case in which four people "Sampled" the same car of bottles for a minor fault. Each took a sample of 300 bottles to examine. One found 4.0% defective, another 6.3%, a third 4.6%, and the fourth 2.3%. Thus, one found nearly triple the number found by another "sampler." A great deal of kidding followed, running from "better get some new glasses" to "must be seeing double today," yet these four people were in rather good agreement statistically. The average of their results was 4.3%. It would have been reasonable under these conditions (and it can be proven mathematically) to expect values ranging from 0.9% to 7.8%. Just how, and why, we will show later.

If each sampler had looked at only 100 bottles, and if the same average, 4.3%, had been found for the results of all four combined, mathematical calculations show that their individual values might range from 0 to 10.4%. If each had looked at 1000 bottles, the range would have narrowed to between 2.4% and 6.2%. Examining still larger numbers would have increasingly narrowed the range. Choice of the size of the sample would be governed by the degree of certainty desired and its cost.

What is needed is a sampling plan that will call for a sample just large enough to result in an evaluation reasonably close to the true condition of the shipment to satisfy the needs of the seller and buyer. By "reasonably close" we do not imply an exact answer—that would be possible generally only by examining or testing every item in the shipment; we do mean that the evaluation should be close enough to the true condition that the probable error is within limits with which we are willing to work.

And yet, many of us have been content to take a couple of dozen bottles from a car and pass or reject the carload on the basis of values a fraction of a per cent above or below some fixed value. We have even been told of people who base everything on three bottles from a carload. On the other hand, so thorough-going a group as the American Society for Testing Materials, whose business it is to evaluate testing methods, has specified a *minimum of* 100 *bottles from* each *truckload*, or *carload*, for *each of the* three test methods it recognizes for glass containers—

(*Continued on page* 100)

NATURAL GAS OUTLOOK FOR THE GLASS INDUSTRY

By FRANKLIN T. RAINEY, General Sales Manager

The Ohio Fuel Gas Company

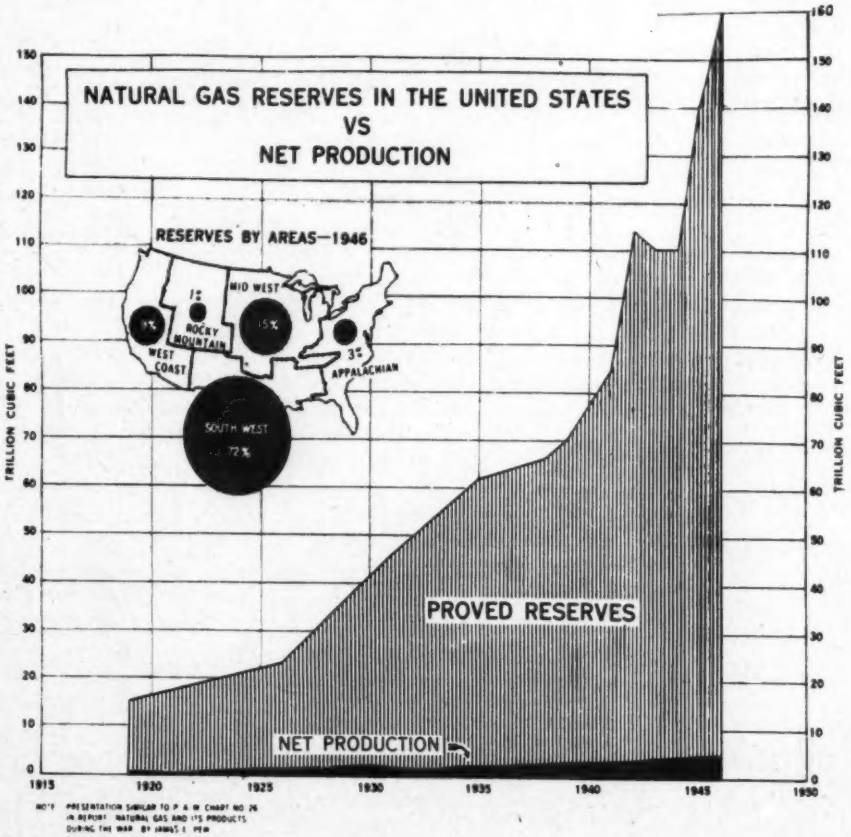
The gas industry is a large supplier of fuel for many of the manufacturing processes of glass and, consequently, the problems of each industry have a far-reaching effect on each other. The greatest problem confronting the glass industry is that of natural gas supplies for many glass-making operations.

The natural gas industry, like many others, has had tremendous growth over the last several years. In many cases, the demand for natural gas has risen to an all time peak and, in some instances, the demand has increased 100 per cent over that of the prewar years. Along with this increasing demand, it has been impossible to secure sufficient steel for pipe lines, and other materials necessary to keep facilities in step with growth. So great has been this demand, both domestic and industrial, that gas companies serving over 60 per cent of all the gas consumers in the United States have found it necessary to put into effect restrictive policies limiting new uses of gas. Most of these restrictions apply to the use of gas for space heating purposes, although some companies are denying new applications for further expansion of industrial service. Those companies now allowed to take on additional industrial service are taking it on, on an interruptible basis, which provides for curtailment during peak winter requirements. Most of the glass companies have assisted materially in solving these restrictive policies by the installation of stand-by equipment utilizing other fuels. It is the aim and the objective of all gas utilities to discontinue these restrictive measures as soon as sufficient quantities of steel and other materials become available, in order to bring the gas supply and distribution facilities in line with requirements. Hundreds of millions of dollars have already been appropriated and are being spent by the gas industry for carrying out this program, and the rapidity with which such a program will be completed will be directly proportional to the availability of these materials.

Naturally, the glass industry is interested in the outlook for natural gas for the future. Every day, such questions as, "Is there a shortage of natural gas?" "How many years will the gas supply last?" "How can the utilities operate and maintain good service when their winter requirements are three to six times that of their summer requirements?" and countless others are asked.

First, consider the matter of natural gas supply and the reserves behind this supply. Estimates of gas reserves have been made for many years, and one of the noteworthy facts in this connection is that the total supply has steadily increased during this period. One of the earliest estimates was made by Shaw in 1919, in which the United States Natural Gas Reserves were found to be fifteen trillion cubic feet. The total reserves, at the end of 1946, as computed by the American Gas Association's Committee on Reserves, was 160 trillion cubic feet. In arriving at this total gas reserve figure of 160 trillion cubic feet, only those fields having individual reserves of 20 billion cubic feet or more were included. If there be added to this estimate the 6,000 smaller fields not included therein, it is estimated that total natural gas reserves today would be somewhere in the magnitude of 200 trillion cubic feet.

With extensive drilling and growing demands, it is only natural that gas reserves should continue to in-



NOTE: PRESENTATION SIMILAR TO P. A. W. CHART NO. 76 IN REPORT "NATURAL GAS AND ITS PRODUCTS DURING THE WAR" BY JAMES E. PEW

Presented before the Ninth Conference on Glass Problems, University of Illinois, Urbana, Illinois on December 4, 1947.

crease for some time. The remarkable fact is that the increase has grown year by year and, for the country as a whole, it has far outreached even the tremendous increased demand. Mr. E. Holley Poe, who has had long experience in the natural gas industry, stated recently in a hearing in Washington, "As long as the curve representing reserves continues upward, away from the consumption curve and at a sharper angle, the dependability of natural gas as an abundantly natural resource will become greater and greater. Concern for the supply can be justified only when the reserve curve shows a continued tendency to dip toward the consumption curve."

These reserves have not increased in all fields, for some are old from the standpoint of production and have been more heavily drawn upon because the reserves, at the outset, were less, the producing areas were smaller and the reserves thinner and fewer. Appalachian reserves never were as great as southwestern reserves, for these and possibly additional reasons: Appalachian production reached its peak in 1917 when 522 billion cubic feet were produced and delivered to market. The southwestern states, on the other hand, increased year by year, until in 1946 they had an estimated production of 3½ trillion cubic feet.

In Table I, the various states have been grouped as Appalachian, Southwestern and All Others. This table shows reserves on December 31, 1945, with additional discoveries during 1946. Production in that year was the net difference between discovered and produced volume, and the resulting reserves on December 31, 1946. This table is adapted from the American Gas Association's Committee on Reserves. It shows, among other things, that the Appalachian area produced 175 billion cubic feet more gas than was discovered during the year, whereas Texas added by new discoveries during the year, 8 trillion cubic feet more than the 2 trillion produced.

Table II is intended to show approximate relationships for various states and districts. It also shows the number

(*Continued on page* 108)

TABLE II

RESERVES AND YEARS REMAINING AT 1946 RATES OF PRODUCTION
(*Reserves and Production—Millions Cubic Feet*)

	Reserves on 12-31-46	Production Year 1946	Equivalent Years Remaining
Appalachian			
Kentucky	1,386,000	95,000	14.6
New York	69,900	7,000	10.0
Ohio	614,000	59,000	10.4
Pennsylvania	503,000	78,000	6.4
West Virginia	1,840,000	205,000	9.0
Total	4,412,900	444,000	9.9
Southwestern			
Kansas	13,680,844	206,532	66.2
Louisiana	22,411,511	607,932	36.7
Oklahoma	10,735,846	655,908	16.4
Texas	86,363,459	2,097,238	41.2
Total	133,191,659	3,567,610	37.3
All Other U. S.	22,971,342	931,007	24.7
GRAND TOTAL	160,575,902	4,942,617	32.5

TABLE I

RESERVES IN UNITED STATES
(*Millions Cubic Feet*)
YEAR 1946

Province State	Reserves 12-31-45	Reserves Added by Discoveries, Extensions, Etc.	Production	Net Change of Reserves 12-31-45	Reserves on 12-31-46
Appalachian					
Kentucky	1,436,800	44,200	95,000	50,800*	1,386,000
New York	76,000	1,900	7,000	6,100*	69,900
Ohio	626,800	46,200	59,000	12,800*	614,000
Pennsylvania	520,000	61,000	78,000	17,000*	503,000
West Virginia	1,928,300	116,700	205,000	88,300*	1,840,000
Total	4,587,900	269,000	444,000	175,000*	4,412,900
*Decrease					
Southwestern					
Kansas	13,250,605	636,771	206,532	430,239	13,680,844
Louisiana	19,849,393	3,170,050	607,932	2,562,118	22,411,511
Oklahoma	10,079,938	1,311,816	655,908	655,908	10,735,846
Texas	78,306,676	10,154,021	2,097,238	8,056,783	86,363,459
Total	121,486,612	15,272,658	3,567,610	11,705,048	133,191,659
All Other States	21,714,855	2,187,494	951,007	1,256,487	22,971,342
GRAND TOTAL	147,789,367	17,729,152	4,942,617	12,786,535	160,575,902

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Glass Compositions

Corning Colored Glass. Fig. 1. Patent No. 2,433,882. This patent is a continuation in part of the application resulting in Patent No. 2,409,412 (see GLASS INDUSTRY, Nov. 1946, page 560). It is the invention of William H. Armistead, who assigned it to Corning Glass Works. The glass of this patent has a sharp cutoff for blue and violet light and a sharp cutoff and absorption for red light. The glass is colored green by a halide of iron combined with a halide of cobalt and transmits only green light.

This glass consists essentially of silica, boric oxide, alkali metal oxide (R_2O), at least 10% Al_2O_3, up to 2.5% of oxides of iron and cobalt and at least 0.5% of a halide (chloride, bromide or iodide) as determined by analysis.

The following table gives examples of some compositions in accordance with this patent, the compositions being calculated from their batches into approximate weight per cent on the oxide basis.

	A	B	C	D	E	F	G
SiO_2	45	45	45	57	30	42	45
B_2O_3	20	20	20	25	35	20	15
Al_2O_3	20	20	20	10	20	20	21
K_2O	10	10	10	...	15	15	16
Na_2O	5	5	5	8	...	3	3
Co_2O_3	0.05	0.1	0.3	0.1	0.02	0.2	0.05
Fe_2O_3	0.05	0.1	0.3	0.05	0.02	0.1	0.1
Per cent Cl by analysis	1.4	1.4	1.4	.79	.63	.93	.74
Per cent R_2O added as halide	5	5	5	4	4	5	3
Per cent Na_2O added as Na_2SiF_6	5	5	5	...	...	3	3

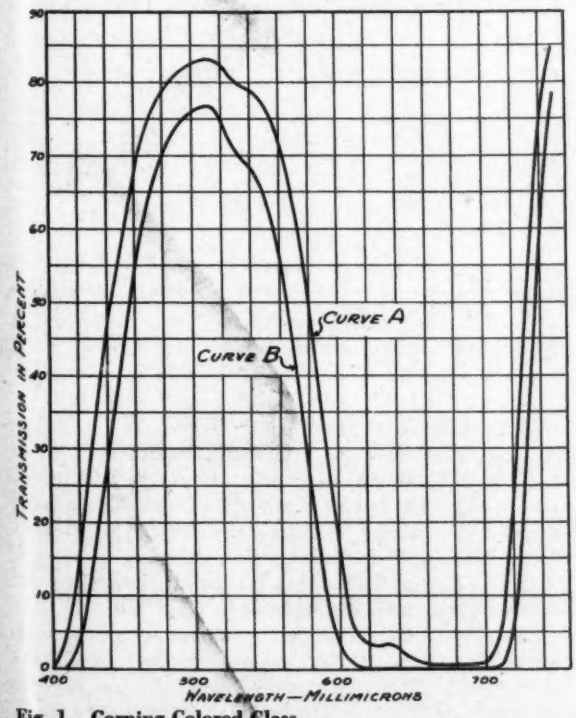


Fig. 1. Corning Colored Glass.

Fig. 1 is a graph showing curves representing transmission in per cent plotted against wave lengths of visible light. Curve A shows the transmission characteristics of glass A in the above table while curve B applies to glass B, the thickness of each being about 5 mm.

This patent shows no references cited by the Patent Office during its prosecution.

Corning Optical Glass. Patent No. 2,433,883. This glass is particularly adapted for sealing to crown glass in the manufacture of multifocal lenses. It was invented by William H. Armistead and assigned to Corning Glass Works. The patent goes into some detail as to the ophthalmic requirements of such glasses. The glass makers' view of the invention can be had from the following six examples of different glass compositions coming within the scope of this invention. The compositions are given in weight percentage as calculated from their batches.

	1	2	3	4	5	6
SiO_2	50.9	50.9	50	47.5	44.5	37.5
B_2O_3	6	4	2	4	4	4
ZrO_2	10.2	10.2	10	8	7	5.5
BaO	10	12	...	18	20	20
ZnO	12	10	12	5	7.5	10
Li_2O	2.8	3	2	2	2	2
Na_2O	8.1	7.9	12	7.5	6.0	4.5
Al_2O_3	...	2	2	2	2	2
CaO	...	...	10	5	5	10
TiO_2	...	...	...	1	2	4.5
Softening Point, °C.	650	664	675	666	667	662
Exp. Coeff. $\times 10^7$	...	83.3	88.8	88.3	86.4	90
nD	1.5880	1.5882	1.5900	1.6051	1.6163	1.6537
ν	53.3	53.2	52.1	52.2	50.6	46.1

Compositions 5 and 6 are particularly suitable for combination with standard optical crown glass to produce bifocal lenses.

There is no record of any patents having been cited by the Patent Office during the prosecution of this application.

Corning Ultraviolet Transmitting Glass. Patent No. 2,433,928. This patent aims to improve the stability of ultraviolet glass particularly as to weathering under atmospheric conditions. It is the invention of John L. Sheldon, who assigned it to Corning Glass Works. This patent is a continuation in part of an abandoned application filed Sept. 29, 1941, Serial No. 412,888.

A glass suitable for enclosure of mercury vapor arcs is disclosed in Patent No. 2,382,056 to Harrison P. Hood but this glass is subject to discoloration due to its high boric oxide content. Mr. Sheldon provides a method of preventing the weathering of borosilicate glass articles and a new glass composition which will not discolor in use.

According to this patent, borosilicate glass containing from 15 to 55% boric oxide is treated for at least one hour in water not over 100°F. After this the glass is heated to near its annealing temperature from one to three hours. It is preferred to use water in a gaseous

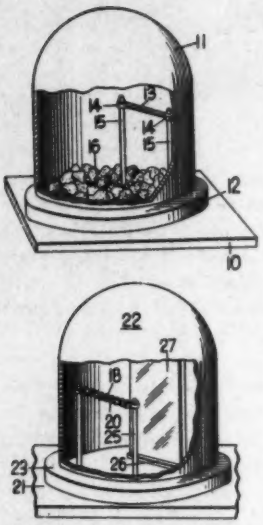


Fig. 2. Method of Coating Glass with Quartz.

state and this may be done by using a warm humid atmosphere having a humidity of at least 50%. The time required for treatment will vary but glass containing alkali metal oxide and about 25% B_2O_3 can be treated by exposing it to atmosphere during the hot humid summer months. A treatment in liquid water shortens the time required.

The patent gives full directions for carrying out the invention and the claims are directed to the method of treating glass and to glass which has been so treated.

Claim 10 is as follows: An article composed of an alkali - alumina - borosilicate glass which contains from 15% to 40% B_2O_3 and which has been treated for at least one hour with fluid water at a temperature not exceeding about 100°F., and thereafter heated for one to three hours near its annealing temperature, the glass having a transmission for wave length 185 mμ, which is higher than the transmission of the initial glass by an average of about 20%.

The patent shows no references cited by the Patent Office during prosecution.

Corning Blue Glass. Patent No. 2,434,139. This is the invention of William H. Armistead, who assigned it to Corning Glass Works. It relates to borosilicate glasses colored with cobalt and containing chlorine for the purpose of modifying the color, as shown in the patent to Taylor, No. 1,572,625. This invention increases the chemical durability of earlier glasses and improves the color. It is recommended that the melting be done in closed pots to prevent excessive loss of chloride.

The following compositions in per cent by weight show five glasses made in accordance with the invention as compared with the prior glasses, as shown in examples VI and VII. The compositions were calculated from their respective batches into approximate weight per cent on the oxide basis. The analytical chloride content of each glass is shown.

	I	II	III	IV	V	VI	VII
SiO_2	53	51	49	67.5	40	47	65
B_2O_3	15	15	15	15.0	20	39	23
Al_2O_3	16	18	20	10.0	20	3	5
K_2O	13	13	13	...	8	11	7
Na_2O	3	3	3	7.5	12	...	...
Co_2O_3	.3	.3	.3	.3	.3	.3	.3
Per cent Cl by analysis..	0.53	0.64	0.74	0.59	0.62	0.26	0.19

Examples VI and VII are in accordance with the Taylor patent above mentioned.

Eastman Kodak Optical Glass. Patent No. 2,434,146. A group of four patents have been issued, all invented by Paul F. DePaolis, who assigned them to Eastman Kodak Company of Rochester, N. Y. The first of these relates to a glass having an index of refraction for the D line (n_D) of the order of 1.71 and an Abbe value (2) of the order of 53.

Two formulas are given in the following table, parts being given by weight:

Oxide of—	A	B
Boron	33.4	35
Aluminum	...	2
Silicon	...	3
Lanthanum	22.2	23
Thorium	22.2	19
Tantalum	...	2
Barium	22.2	8
Strontium	...	8
n_D	1.718	1.71
v	53.5	53

These glasses are of the type shown in Reissue Patent No. 21,175 to Morey but they show improvements over the former patent.

The following references are of record in the file of this patent: United States Patents: 2,241,249, Eberlin, May 6, 1941.

Eastman Kodak Optical Glass. Patent No. 2,434,147. The second of this series of patents by the same inventor relates to a glass having an index of refraction for the D line (n_D) of the order of 1.75 and an Abbe value of the order of 44. These glasses are of the non-silicate type generally covered by Reissue Patent No. 21,175 to Morey. This patent relates particularly to an improvement over the Morey patent which is particularly useful in lenses and other optical instruments.

This invention relates to a glass having substantial amounts, over 10 per cent, of lanthanum, tungsten, and thorium oxides, totaling 60 per cent of the whole batch.

Two examples of the glasses covered by this invention are as follows, the tables also giving certain optical values:

	1	2
Lanthanum oxide	30.0	28.0
Tungsten oxide	18.0	18.0
Thorium oxide	12.0	13.0
Calcium oxide	...	13.0
Zinc oxide	12.0	...
Boric oxide	28.0	28.0
nS	1.76	1.75
v	44.0	44.0

The following references are of record in the file of this patent: United States Patents: 2,241,249, Eberlin et al., May 6, 1941.

Eastman Kodak Optical Glass. Patent No. 2,434,148. This is the third of the group of patents issued in the name of DePaolis and assigned to Eastman Kodak Company. This glass is of the non-silicate type, having boric oxide as a glassifier and generally covered by Reissue Patent No. 21,175 to Morey. This glass has an index of refraction for the D line (n_D) between 1.75 and 1.80 and an Abbe value in the region between 37 and 40.

The glass contains lanthanum, titanium, and thorium oxides in amounts of over 10 per cent each, making a total of about 50 per cent of the batch. A glass made in accordance with this patent has high transparency, hard-

ness, stability and weather resistance, and can be worked to give a high polish.

Two examples of glass made in accordance with this patent are as follows, the oxides of the elements being in proportions by weight:

	Example 1	Example 2
Lanthanum oxide	25.0	20
Titanium oxide	12.5	15
Thorium oxide	12.5	15
Tungsten oxide	...	5
Barium oxide	15.0	...
Strontium oxide	5.0	...
Calcium oxide	4.0	...
Cadmium oxide	2.0	15
Aluminum oxide	1.0	2
Boric oxide	22.0	28
n_D	1.775	1.75
v	37.5	40.0

No references were cited by the Patent Office against this application.

Eastman Kodak Optical Glass. Patent No. 2,434,149. This patent is the last of a series of four inventions by DePaolis and assigned to Eastman. The glass of this patent has an index of refraction for the D line (n_D) between 1.80 and 1.82 and an Abbe value between 40 and 42. This glass is of the non-silicate type such as is covered by Reissue Patent No. 21,175 to Morey and Patent No. 2,206,081 to Eberlin.

Four examples of this new glass are given in the following table, but these examples are to be understood as being read by a man skilled in the art of glass making:

	Example 1	Example 2	Example 3	Example 4
Lanthanum oxide	26	27	40	32
Tantalum oxide.	15	16	13	15
Thorium oxide..	18	16	5	20
Tungsten oxide..	12	2	...	...
Zirconium oxide	...	12	2	...
Titanium oxide..	...	...	4	2
Barium oxide...	2	...	2.5	2
Strontium oxide.	...	...	4	...
Boric oxide.....	22	24	22.8	23
Silicon oxide...	5	...	2.5	5
Aluminum oxide	...	3	4	1
Lithium oxide...	...	...	0.2	...
n_D	1.8055	1.8042	1.8036	1.815
v	40.3	40.4	41.5	41.7

The following references are of record in the file of this patent: United States Patents: Re. 21,175, Morey, Aug. 15, 1939, and 2,241,249, Eberlin et al., May 6, 1941.

Miscellaneous Processes

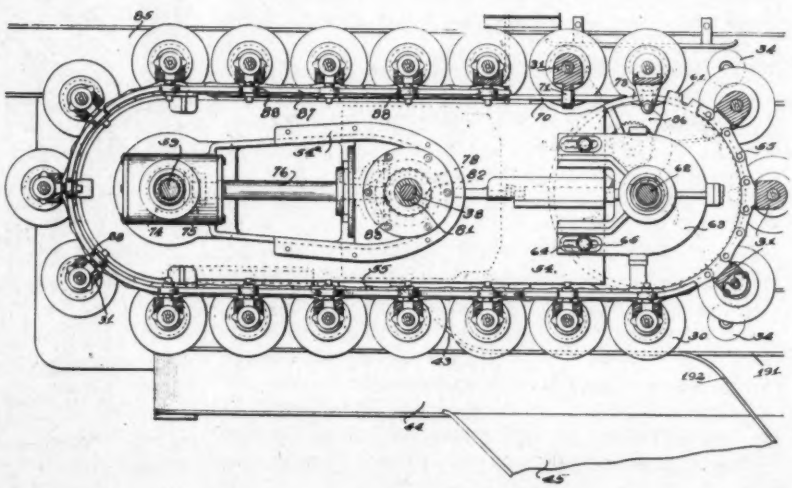
Method of Coating Glass with Quartz. Fig. 2. Patent No. 2,432,538. This patent has to do with depositing a thick and uniform coating of quartz on glass used for mirrors and similar purposes. It is the invention of James C. Ogle, Jr., and Arthur R. Weinrich of Brackenridge, Pa., who assigned it to Libby-Owens-Ford Glass Company. The patent is a continuation in part of the application which resulted in Patent No. 2,386,876.

It is well known that quartz makes the best protective covering for mirrors and reflectors but previous attempts to produce such coatings have not been successful. This patent provides a method of evaporating quartz so as to deposit a protective coating by thermal evaporation on the previously prepared glass. This method includes the steps of placing quartz which has its surface coated with beryllium in a vacuum chamber, and heating the quartz by an electrically heated filament to evaporate the quartz and deposit it on a supporting surface such as glass.

The upper part of the figure shows the apparatus for applying a metal coating to the quartz. A base 10 supports a bell jar 11 enclosing a heating coil 13 carried by supports 14 and 15. Quartz pieces 16 are placed on the base and the metal with which the coil has been coated is deposited on the quartz. Some metals which may be used for this purpose are beryllium, titanium or zinc. The metal-coated quartz 18 is then placed in an electric coil 20 as shown in the lower part of the figure. This apparatus is very similar to that used to deposit the metal on the quartz (upper part of figure). A housing 22 rests on a base 21 which also carries posts 25 to support the coil. The base is provided with a support 26 which holds the mirror 27 to be coated. When the coil is heated, the metal-coated quartz will adhere to the filament and, in effect, wet it. At this time, the metal-coated quartz develops a superficial molten phase. The heat must be more than 1500°C., while the quartz is in a vacuum. In this way a mirror is prepared having a glass base, a reflective or mirrored surface and a relatively thick protective coating of quartz on the reflective surface.

The following references are of record in the file of this patent: United States Patents: 2,386,876, Ogle, Jr., et al., Oct. 16, 1945, and 2,413,606, Colbert et al., Dec. 31, 1946.

Owens Bottle Testing Machine. Fig. 3. Patent No. 2,432,871. This patent has for its object the automatic inspection of bottles and similar containers, to detect small leaks or pinhole openings through the glass or imperfections in the finish which cannot be detected by the usual methods of inspection. It is the invention of William J. Fedorchak and Albert S. Jackson, who assigned it to Owens-Illinois Glass Company. This patent was



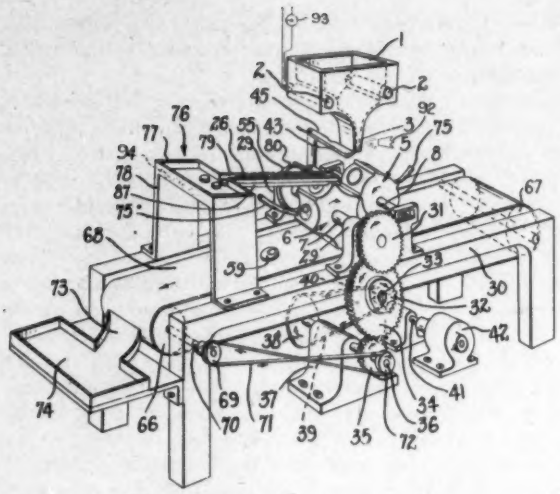


Fig. 4. Lens Forming Machine.

divided from an application resulting in Patent No. 2,352,091, dated June 20, 1944.

The machine of this patent is for automatically testing bottles and similar ware, to detect small leaks, bad finishes, crooked necks and other defects and to reject all imperfect ware while the perfect ware passes on to the packing table. As shown in Fig. 3, the machine comprises a series of gauging units 30 carried by an endless chain, a part of which travels above a conveyor 85 which brings in the bottles 34 to be tested. Each unit or head has a frame 31 which carries a spindle capable of rotation and vertical movement. This spindle serves as a gauge when it is lowered into the bottle and if it fails to enter and close the neck of the bottle, it prevents a vacuum from being formed so that the bottle can be lifted by the spindle. If the vacuum fails to hold the bottle for any reason, the bottle will be dropped back onto the conveyor 85 and it will be carried to cullet. If there is a slow leak from any cause, the bottle will lose its vacuum and be dropped onto the conveyor 191 from which it is pushed by a deflector 43 and by a second deflector 192, onto a table 45.

Patent No. 2,352,091, from which this application was divided, shows certain other gauging operations performed by the present invention. Bottles which pass all tests are carried off on a conveyor 191. The patent discloses mechanism which makes the testing operation fully automatic.

The following references are of record in the file of this patent: United States Patents: 469,302, Page, Feb. 23, 1892; 498,408, Roth, May 30, 1893; 2,309,231, Bagley, Jan. 26, 1943; 2,314,310, Jackson et al., Mar. 16, 1943; 410,300 Steegmuller, Sept. 3, 1889; 603,874, Christie, May 10, 1898; and 2,177,019, Egenolf, Oct. 24, 1939.

Lens Forming Machine. Fig. 4. Patent No. 2,433,013. This is the invention of Byron J. Ziegler of West Dudley, Mass., who assigned it to American Optical Company.

The patent states that there are seven objects of the invention, the final result of which is to produce an optical lens blank. As shown in the figure, glass for forming the major portion of a bifocal lens is placed in a tank 1. This glass flows out through a nozzle 3 to molding dies 5 and 6. At the proper time gears 31 and 32 rotate the dies 5 and 6 while the severing blade 43 cuts off the proper amount of glass. The pressed blanks fall onto a belt 68 which delivers them to a receptacle 74.

The patent should be examined for details of the invention.

Westinghouse Device for Making Fluorescent Tubing. Fig. 5. Patent No. 2,433,116. This patent relates to the manufacture of glass tubing and the application of fluorescent coating to the tubing while it is being made. It is the invention of James W. Greenbowe, East Orange, Alfred H. Laidig, Bloomfield, and William F. Kelley, Jr., West Caldwell, all in New Jersey. The patent was assigned to Westinghouse Electric Corporation.

The invention draws glass downwardly from an orifice to form the tube and at the same time deposits a dry fluorescent powder on the inside of the soft glass.

Fig. 5 is a vertical section of the apparatus, in which a glass furnace 11 contains glass at a temperature of from 1200 to 1300°C. The bottom of the furnace has an opening 13 and a die 14 preferably made of an alloy of platinum and rhodium as described in Patent No. 2,190,296 to Richardson. A fixed mandrel 15 covered by a shell 60 of the above described alloy is suspended from a control block 20 which can be adjusted vertically by a chain 36 passing around a sprocket wheel 35. A radiation pyrometer 45 controls the heat of the furnace in the manner shown in Patent No. 2,116,450 to Richardson. Cooling devices are provided which may be in the form shown in a certain co-pending application of Laidig, et al.

The fluorescent material is supplied in the form of a smoke admitted through ports 51. This smoke may be

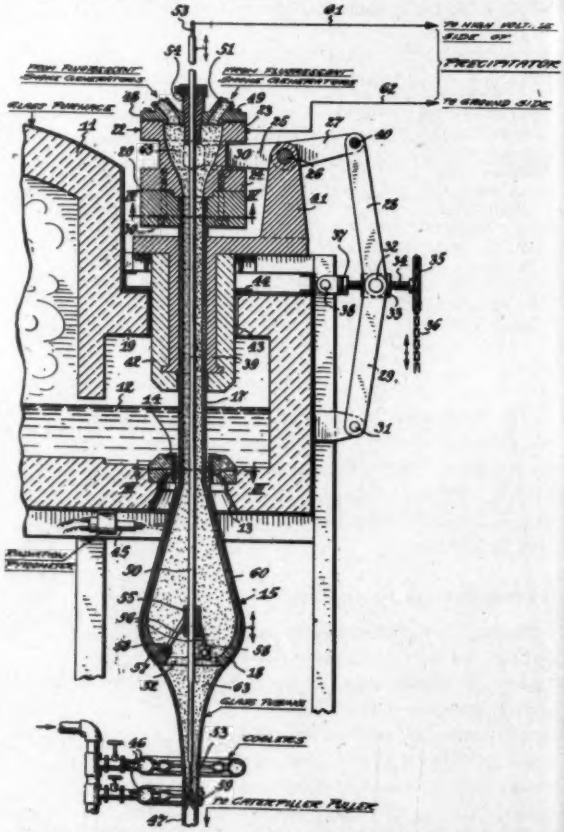


Fig. 5. Westinghouse Device for Making Fluorescent Tubing.

supplied in the manner set forth in Patent No. 2,426,016 to Gustin et al. In order to assist in the deposition of the fluorescent material, an electrode 53 is provided. This is connected to the positive side of a high voltage electrostatic precipitator as shown in the Penney Patent No. 2,129,783.

The following references are of record in the file of this patent: United States Patents: 2,009,793, Sanchez-Vello, July 30, 1935; 2,181,305, Myers, Nov. 28, 1939; 2,207,174, Jenkins, July 9, 1940; 1,926,410, Soubier, Sept. 12, 1933; 1,926,905, Le Coultre, Sept. 12, 1933; 2,237,754, Davies, Apr. 8, 1941; 2,310,474, Teichmann, Feb. 9, 1943; 1,698,845, Gustin, Jan. 15, 1929; 2,094,242, Parker, Sept. 28, 1937; and 2,370,618, Danner, Mar. 6, 1945. Foreign Patents: 367,614, Great Britain, Feb. 25, 1932; 693,153, France, Aug. 18, 1930; 38,432, France, Mar. 3, 1931; 750,425, France, May 29, 1933; and 431,408, Great Britain, July 8, 1935.

Method of Coloring Glass Fibers. Patent No. 2,433,292. This is the invention of Jack W. Perloff, who assigned the patent to Owens-Corning Fiberglas Corporation.

Up to the present, it has not been possible to color fine glass fibers on a commercial scale by the use of colored glass as a base material except in a few colors. The application of color to the fiber has had small success. One example of the use of this invention to color a glass fabric provides that the fabric be first cleaned to remove any binder or other material that may be on the surface of the glass and then impregnating with a solution of hectorite. The film thus formed will, after drying, hold various dyes for long periods and while subject to many uses.

The hectorite is preferably fixed by a solution of a metallic salt such as acetate of lead, magnesium, uranium and copper and nitrates of zinc, nickel and copper.

The following references are of record in the file of this patent: United States Patents: 2,138,882, Robie, Dec. 6, 1938; 2,145,235, Cryor, Jan. 31, 1939; 2,184,316, Plummer, Dec. 26, 1939; 2,245,783, Hyde, June 17, 1941; and 2,309,962, Kraus, Feb. 2, 1943.

Fish-net Float. Fig. 6. Patent No. 2,433,399. This patent shows a method of making glass floats used on fish nets but it can be used in the manufacture of any sealed glass body such, for example, as building blocks. It is the invention of Gordon W. Roessler and Ray A. Chilcote, who assigned it to Northwestern Glass Company of Seattle, Washington.

These floats might be described as spherical bottles having the necks sealed. It is important that all parts of the float, including the seal, shall be strong enough to withstand the great pressure encountered when they are submerged in water to a depth of 750 feet or more. It is not practical to seal the blow opening of the float at the time it is made as the vacuum produced on cooling would cause the float to collapse.

This invention makes floats on what appears to be a Hartford I-S machine. A parison is formed in the usual way but the neck pin is much smaller than would be used in making a bottle. The parison is transferred to the blow mold, blown and then set out on a conveyor. After it has cooled slightly, the finish is reheated to the softening point and a plunger closes the blow opening.

The upper part of Fig. 6 shows a blow mold 31 in which the parison 29 shown in dotted lines has been blown to form a float 32 having a protuberance 90 in which there is a small blow opening 30. It will be seen that the upper end of the float corresponds roughly to the finish of a bottle so that it can be handled in the same way. The float is then picked up by the take-out, placed on a dead plate where it is cooled and then pushed onto a conveyor, all in the usual way. After travelling a short distance, a group of four floats is picked up by jaws so as to clear the conveyor belt. At this time three of the floats are positioned below oxy-acetylene burners which heat the protuberance 90. At the same time the foremost float which has been heated is below a plunger which descends and presses the soft protuberance, closing the blow opening and forming a seal as indicated at 99. The groove 92 provides a convenient means for attaching the net. Automatic mechanism is provided for performing all the operations.

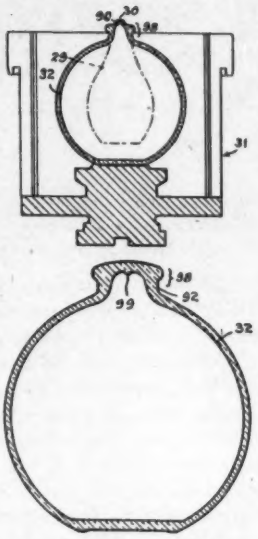


Fig. 6. Fish-net Float.

The following references are of record in the file of this patent: United States Patents: 1,937,289, McSwain, Nov. 28, 1933; 2,076,502, Moscini, Apr. 6, 1937; 1,804,084, Blake, May 5, 1931; 1,561,808, Towne, Nov. 17, 1925; 2,031,660, Loepsinger, Feb. 25, 1936; 1,949,901, Cosch, Mar. 6, 1934; 910,120, Edmonds, Jan. 19, 1909; and 1,413,169, Lawton, Apr. 8, 1922.

Method of Purifying Glass Sand. Patent No. 2,433,633. It is well known that iron in any form should be found in glass sand only in very minute amounts. This invention provides a way to reduce the iron content of glass sand to an insignificant amount. The method was invented by Edwin B. Stokes of Lakeland, Florida, who assigned the patent to Minerals Separation North America Corporation of New York City.

This inventor has discovered that after glass sand has been subjected to froth-flotation treatment in the presence of a cationic amine compound, the quartz froth-float can be further purified by subjecting it to froth-flotation treatment after conditioning it in an aqueous pulp merely with a small amount of a mineral acid.

In brief, the invention consists of a process for reducing ferruginous impurities in glass sands by the steps of subjecting the sands to froth-flotation treatment in an aqueous pulp in the presence of a cationic amine compound and treating the resulting product to froth-flotation followed by the removal of ferruginous froth.

Three examples of this method are given in the patent, the first of which is as follows:

Glass sand was reduced to minus-20-mesh, acid treated, deslimed and subjected to a caustic wash. The sand then contained about 0.042% Fe_2O_3. The sand was then conditioned for about two minutes in an aqueous pulp containing about 70% solids, with 1.0 lb. NaOH, 0.4 lb. of

(Continued on page 109)

Research Digest

Studies in the Distribution of Temperature Through Molten Glass in a Tank-Melting Furnace

Previous communications on this subject have shown the type of gradient which exists through various colorless and colored commercial glasses when maintained at a constant temperature in a small laboratory furnace. These measurements were carried out on comparatively small masses of glass with glass depths not exceeding 5 inches and with a ratio of refractory to glass much greater than is the case in a commercial tank furnace. It was therefore important to ascertain how far the type of temperature distribution, established on the small scale, holds good in the case of industrial glass-melting furnace. Halle (*Journal of the Society of Glass Technology*, June-August 1947) reports Part V of this subject dealing with the temperature distribution in commercial tank-melting furnaces.

The temperatures from surface to bottom of ten different glasses in commercial tank furnaces were determined by three different methods of measurement. With one exception all determinations were carried out in the working chamber of the furnace. The gradients, defined by the difference in temperature between glass 8 inches below the surface and lower depths, varied from 1°C. per inch in the case of a "Pyrex" glass with a total iron oxide content of 0.088 per cent to 17°C. per inch for a dark-green bottle glass containing 1.28 per cent total iron oxide, in addition to 0.68 per cent MnO and 0.48 per cent Cr_2O_3. Table I lists the temperature gradients found in these various furnaces:

TABLE I

No.	Type of Glass	Gradient °C. per in.	Total Iron Fe_2O_3	Other Coloring Oxides
1	Pyrex	1	0.088%	....
2	Colorless illuminating	2	0.055	....
3	Colorless pressed	2	0.055	....
4	Colorless pressed	3	0.055	....
5	Colorless container	3	0.067	....
6	Pale green bottle	4	0.13	0.27 % MnO
7	Green bottle	7	0.26	0.46 % MnO
8	Smoky brown sealing	11	0.18	0.012% CoO
9	Amber bottle	13	0.51	....
10	Dark green bottle	17	1.28	0.68 % MnO +0.48 % Cr_2O_3

At the conclusion of each determination, a sample of each glass was taken from the commercial furnace and its temperature gradient determined in the standard laboratory furnace. Table II summarizes these laboratory results:

TABLE II

TEMPERATURE GRADIENTS AS MEASURED IN THE LABORATORY FURNACE

Glass No.	1	2	3	4	5	6	7	8	9	10
Gradient °C. per in.	5	8	8	8	9	22	27	40	55	62

These laboratory tank gradients were plotted against the gradients existing in the industrial furnace and a curve of "best fit" calculated statistically. A high degree of correlation between the commercial scale and the laboratory scale temperature gradients was established, a fact of much practical importance, for it becomes possible to forecast the likely temperature for any type of glass in a commercial furnace. All that is required is to melt such a glass in the particular laboratory furnace used for establishing a correlation and to deduce the gradient for the large scale furnace by the curve obtained.

An attempt was also made to show the relation between iron oxide concentration and the temperature gradients in glasses in commercial tank furnaces. The relationship is affected by the presence in four of the five colored glasses of one or more additional coloring oxides. Despite this complication and the added fact that the different tanks varied considerably in depth, there was an indication that iron oxide plays a predominate part in the heat transmission of all of these molten glasses.

A comparison between the results obtained by the present investigation and that of Holscher, Rough and Plummer (*Journal of the American Ceramic Society*, 1943, 26, 398) was also made (Table III). This close agreement of measurements taken by different investigators under different experimental conditions showed that the method and the results described in the present investigation can yield reliable and useful results.

TABLE III

Glass	Temperature Gradients H., R. and P.	°C. per inch Halle
Colorless	4	3
Pale green	6	7
Carbon-sulphur amber	12	13
Dark green (Fe-Mn)	17	17

The Constitution of Colored Glasses

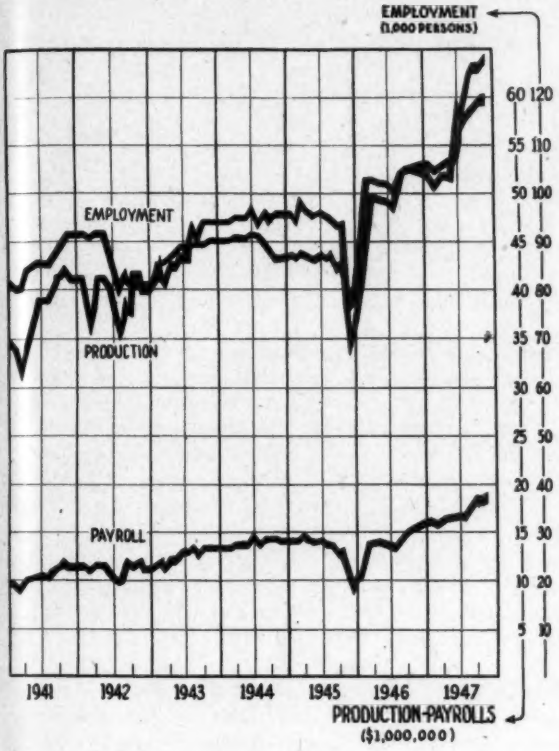
H. Cole (*Journal of the Society of Glass Technology*, June-August 1947) classifies coloring agents in glass on the basis of the analogy between glasses and solutions. It is suggested that the colors of sulphur-amber glasses are produced by the existence in the actual glass structure of molecular groupings of the type –S–S–Fe. Fluoride opals and glasses colored by cadmium sulphide are considered as examples of solid-phase colorings, containing a certain amount of dissolved fluoride or sulphide as part of the structural network.

These theoretical considerations have enabled the control of amber glasses on a production scale to be maintained. For example, from a detailed study of sulphur-amber glasses, the following deductions on color production and control may be made: 1) For constant color, the sulphur, iron and reducing agent must be kept constant. 2) A greenish shade is due to excess oxidized iron (excess

(*Continued on page* 90)

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



According to the Production Index, activity in the glass industry during the month of November 1947 rose about 2 per cent over the previous month. The November production figure is an approximate $64,750,000, as compared with $63,500,000 reported for October. Activity during November 1946 was $56,000,000, which is about 15 per cent below November 1947. Total output for the January-November 1947 period is an estimated $656,250,000, as compared with $548,500,000 during the same period in 1946.

Employment and payrolls: The total number of persons employed during the month of November 1947 was 120,000. This is only slightly more than the 119,700 reported for October 1947. During November 1946, employment was reported at 104,500 persons.

During November 1947, payrolls in the glass industry reached an estimated total of $18,500,000. This figure represents an increase of a little more than 2 per cent over the previous month's figure of $18,000,000. During November 1946, payrolls had been reported to be $15,700,000, which is about 17 per cent below November this year. Glass manufacturers have paid out approximately $185,000,000 in salaries during the January-November 1947 period, as compared with $144,500,000 paid out during the same period in 1946.

Glass container production for the month of December 1947, based on figures released by the Bureau of Census, closed the year with the lowest single month's production figure during 1947. The figure reported was 7,998,024 gross, which is about 5 per cent below the November figure of 8,429,525 gross. Glass container production during December 1946 was 9,341,215 gross, which is about 14 per cent over December 1947. The total number of glass containers produced during the year 1947 is 115,334,269 gross. During 1946, total glass container production was 115,746,570 gross.

Shipments also represent the lowest 1947 single month's figure and dropped to 7,991,488 gross for December 1947. The November figure was 8,113,222 gross, which is about 1 per cent above December. Shipments during December 1946 were 9,663,285 gross, or 17 per cent above December 1947. Total shipments made during

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production December 1947	*Stocks December 1947*
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries and Cosmetics	Narrow Neck	2,113,893	3,046,813
	Wide Mouth	2,132,549	2,288,340
Dairy Products		321,775	174,183
Home Canning		*	**631,818
Beverages, Returnable		625,248	714,508
Beverages, Non-returnable			
Beer, Returnable		1,285,382	271,094
Beer, Non-returnable		191,643	247,603
Liquors		945,685	378,227
Wines		259,213	198,202
Packers' Tumblers		95,779	106,071
Total		7,998,024	8,056,859

*This figure contained in Wide Mouth total.
**This figure represents Fruit Jars only.

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	December 1947
Narrow Neck Containers	
Foods	481,582
Medicinal & Health Supplies	923,169
Chemical, Household & Industrials	365,418
Beverages, Returnable	525,633
Beverages, Non-returnable	
Beer, Returnable	1,056,861
Beer, Non-returnable	214,412
Liquors	907,925
Wines	259,213
Toiletries & Cosmetics	359,268
Sub-Total (Narrow)	5,093,481
Wide Mouth Containers	
Foods	1,649,670
Dairy Products	383,940
Home Canning	*6,776
Medicinal & Health Supplies	222,473
Chemical, Household, Industrials	53,337
Toiletries & Cosmetics	97,836
Packers' Tumblers	95,779
Sub-Total (Wide)	2,509,811
Total Domestic	7,603,292
Export Shipments	388,196
Total Shipments	7,991,488

*This figure represents Fruit Jars only.

TO HELP YOU KEEP PRODUCTION UP COSTS DOWN

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More efficient and economical service throughout a longer life is the typical record of WALSH REFRACTORIES for the Glass Industry. That's why more and more Glass Tank Operators are specifying money-saving WALSH products:

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FOR OVER 50 YEARS MANUFACTURERS OF HIGH GRADE REFRACTORIES

1947 were 110,428,498 gross, as compared with 116,002,796 gross shipped during 1946.

Stocks on hand at the close of December 1947 were 8,056,859 gross. At the close of November 1947, they were 8,116,577 gross, and at the close of December 1946, they were 3,591,447 gross. It should be noted that stocks of glass containers on hand have been unusually high during 1947. This, too, will explain the difference shown for the year 1947 between the production total of 115,334,269 gross and the shipment total of 110,428,498 gross.

Plate glass production for the month of December 1947, according to the Hughes Statistical Bureau, rose about 7 per cent to 20,088,647 sq. ft. The figure reported for November was 18,776,796 sq. ft. Plate glass production during December 1946 was 18,410,848 sq. ft., which is about 9 per cent below December 1947. This brings plate glass production during 1947 to a total of 252,042,690 sq. ft., as compared with 210,006,188 sq. ft. produced during 1946.

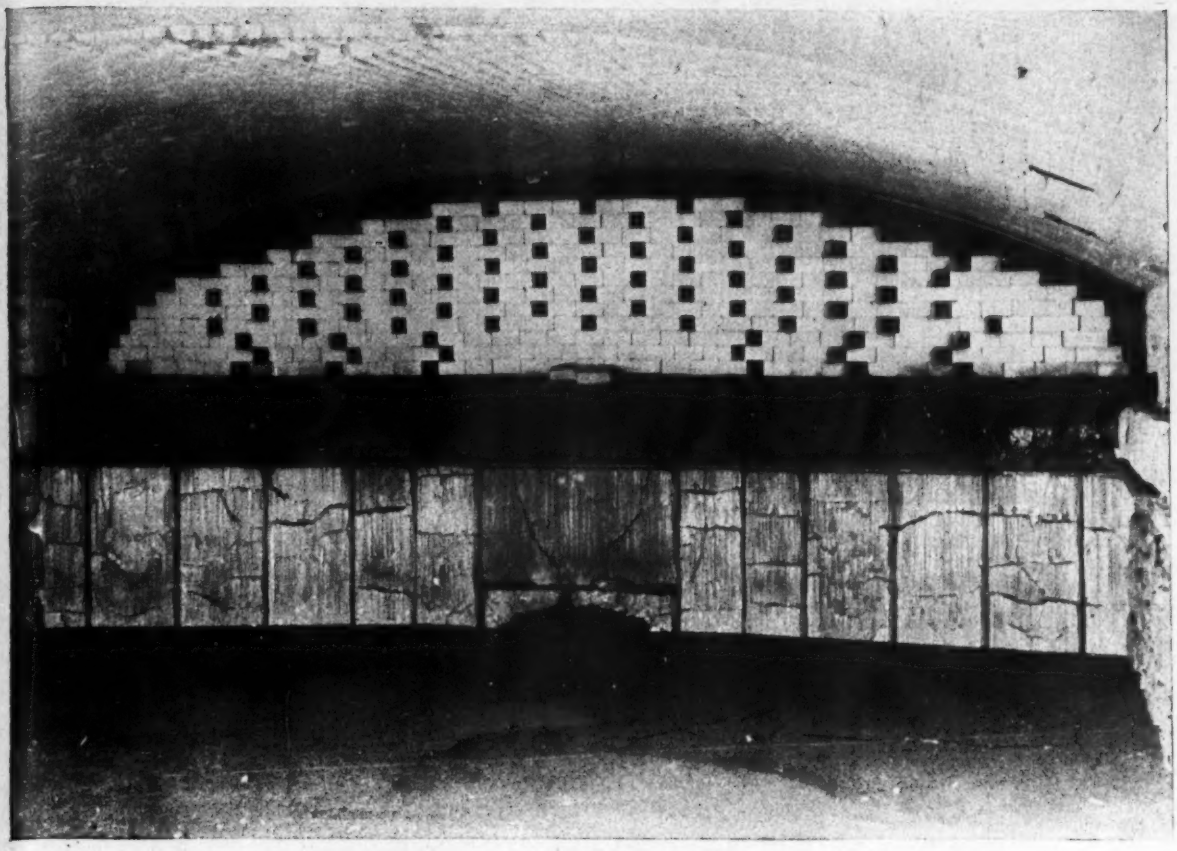
Automatic tumbler production for the month of December 1947 increased close to 6 per cent to a figure of 4,944,176 dozens. The previous month's production figure was 4,674,276 dozens. During December 1946, production was 6,470,409 dozens. Shipments for December 1947 were 4,597,157 dozens, which represents a drop of about 7 per cent from the 4,960,569 dozens shipped during November. During December 1946, 6,241,588 dozens were shipped. Stocks on hand at the close of December were 8, 923,753, as compared with 8,694,157 dozens on hand at the close of November and 4,879,003 dozens on hand at the close of December 1946.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware for the month of December 1947 dropped off about 9 per cent from the previous month's sales. The December sales were 3,793,475 dozens, as compared with 4,180,884 dozens sold during November. Sales during December 1946 were 2,298,384 dozens. Total manufacturers' sales for the 12-month period ending December 1947 were 42,727,814 dozens, as compared with 46,942,453 dozens sold during the corresponding period in 1946.

RESEARCH DIGEST . . .
(*Continued from page* 88)

iron content or insufficient carbon). 3) A brownish amber is probably caused by excess of reduced iron. 4) Increase in iron, sulphur or carbon all produce darkening of the amber color. 5) Excess sulphur tends to produce bubbles noticeably when the surface of the molten glass at working temperature is disturbed. 6) A certain minimum degree of reduction is necessary before any amber color is formed.

• Through an error in the January issue of THE GLASS INDUSTRY, both a picture caption and copy matter referred to the Litton lathe used in the glass blowing course at the University of Delaware as a Hartford-Empire machine. This should have been referred to as an "H-E model Litton lathe" which is a company classification of this machine.



Good Design, Good Operation Good Refractories, Good Results!

OPERATING DATA

Sq. Ft. Melting Area	585
Total Operating Days	626
Idle Days	190
Total Days (Life)	816
Tons of Glass Melted	86659.1
Tons Glass per Sq. Ft. (ME) for Total Life	148.1
Sq. Ft. per Ton per Day (Operating Days)	4.22
Sq. Ft. per Ton per Day (Total Life)	5.5
Tons Coal Used	31085
Tons of Coal Per Ton of Glass (Total Life)	.359

The photograph above shows the bridgewall and throat of a continuous tank which recently completed a campaign on flint bottle glass.

This well designed and well operated tank, constructed with Corhart Zed sidewalls, Corhart Zac bridgewall and throat and Corhart Standard working end walls, set an all-time production record for its operator.

The operating data at the left gives you the interesting part of the story.

Good refractories such as Corhart Electrocast cannot do the job alone, but they play an important part in the success of any glass tank campaign.

We'll be glad to discuss your refractory problems with you. Corhart Refractories Company, Incorporated, 16th and Lee Streets, Louisville 10, Kentucky.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

The words Corhart, Zed and Zac are Registered Trademarks.

NEW EQUIPMENT AND SUPPLIES

MORTAR SEALANT

The American Fluresit Company, 635 Rockdale Avenue, Cincinnati, Ohio, is producing a new mortar sealant for use on glass block. Since the blocks are not porous, ordinary mortar has been found unsatisfactory because it cannot form a good mechanical bond and cracks develop from shrinkage in the mortar. Water is absorbed into these openings and when this water freezes, it cracks the glass block.

The new mortar sealant, known as Klee Sealant for Mortar between Glass Block, coats the exterior mortar joints, adheres to the mortar and forms a tight flexible bond to the glass, expanding and contracting with the mortar, as well as the glass, without rupturing the film. It is of plasticlike consistency, and can readily be applied with a caulking gun, or thinned down with suitable solvents for brushing consistency. The product remains rubbery and bonds tightly to mortar, glass, tile, brick, metal and wood.

NEW HEAVY DUTY LABORATORY CENTRIFUGE

The Gerin Corporation, P. O. Drawer 653, Red Bank, New Jersey, has announced a heavy duty hand power centrifuge designed to swing two or four 100 cc tubes with minimum effort.

Features include ball bearings throughout and a 24-to-1 gear ratio permitting reduced crank speed. The outer diameter of swing is 16 inches and there is a stationary guard bowl to reduce air resistance and protect the operator from whirling parts. The entire unit can be stowed in the bowl when not in use.

FORK-LIFT KILN LOADER

A. D. Alpine, 11837 Teale Street, Culver City, California, has introduced a fork-lift kiln loader that eliminates two handlings of ware in process. Ware can be stacked on the actual setter slabs by the employee performing the last operation before firing. The load is then easily lifted and wheeled into kiln for firing without any unloading and reloading being necessary. Similarly, the fired load can be removed intact from the kiln to the station of the operator who is next to work on the ware.

The Alpine fork-lift kiln loader has a capacity of one ton and is equipped with Aerol lifetime rubber tired wheels. Forks come in two sizes to fit the Alpine HF-12 and HF-20 kilns, and the hydraulic lift has an automatic grip to steady the load and a positive lock to prevent slippage.

NEW TEMPERATURE CONTROLLERS

K. H. Huppert Company, 6830 Cottage Grove Avenue, Chicago 37, Illinois, has introduced a new series of inexpensive temperature controllers designed for use with electric and gas heating units. Available with or without pyrometers, these step-less input controllers are suitable for electric and gas furnaces. ovens, pots and similar applications.

In the operation of this temperature controller, called "Infitrol," a small portion of current is allowed through the heating elements, an amount sufficient to maintain definite temperatures. Since no resistance is used, no current is wasted. Gas equipment is controlled through a solenoid valve.

MICROMAX OXYGEN RECORDING EQUIPMENT

Leeds & Northrup Company, 4934 Stenton Ave., Philadelphia 44, Pa., has developed automatic equipment for measuring the per cent oxygen in flue gases. The equipment is used as a guide to regulating excess air in furnaces such as glass tanks, cement kilns and open-hearth steel furnaces where carbon dioxide is evolved by process reactions. It is also successful as a means of checking combustion in boiler furnaces which fire several different fuels simultaneously or in succession.

CLIPPER ANNOUNCES NEW MASONRY SAW AND DESIGN

Clipper Manufacturing Company, 2800 Warwick, Kansas City 8, Missouri, has incorporated a number of improvements in design of its products. Among the new features are dual belt drive for increased power, snap-on-blade cover, streamlined positions for instant one-man change and fully adjustable conveyor clamps, both elevating and non-elevating types.

Another feature is Clipper's "Multiple Cutting Action," which minimizes the arc of contact and exhausts cut-away particles as soon as they are cut. This allows the blade to cut its own path. The "Multiple Cutting Action" reduces frictional heat, requires less power and keeps the blade sharp for faster cutting and longer blade life.

A new dustless Clipper masonry saw, designated as the HD-48, is said to cut with great speed and ease regardless of whether used "wet" or "dry." When working in closely confined areas, the circulating system is turned on and dust is immediately and completely eliminated. Water is circulated from the reservoir, which is an integral part of the frame, by means of a pump mounted on the cutting head. A stabilizer control is provided to permit exact depth scoring.

CATALOGUES RECEIVED

Kirk & Blum Manufacturing Company, Cincinnati, Ohio, has issued a bulletin, "Cooling Systems for the Glass Industry."

The bulletin opens with a resume of the features of the Kirk & Blum cooling systems, stressing the fact that Kirk & Blum was the first to use the backward curved, non-overloading type fans for either block or mold cooling in a glass plant in this country.

Following the introduction are illustrations of various furnaces and the use of Kirk & Blum cooling systems in connection with these furnaces. The use of the Kirk & Blum cast aluminum nozzles are featured and illustrations given. Descriptive material accompanies these illustrations. Charts and line drawings are included in the bulletin and further illustrative material shows Kirk & Blum cooling as it is applied to individual machines such as Hartford-Empire 5-Section I.S. Machines, Lynch 16 Machine, etc.

Hartford-Empire Company, Hartford 1, Conn., has published two booklets, one "Hartford-Empire Lehrs for Annealing and Decorating," and the other, "Hartford-Empire 28 Machine."

The booklet on lehrs gives practical information, such as descriptions of the equipment, operations, types and sizes, etc. General construction of the lehrs is given and a chart relating to the type of fuel to use with a particular model, belt width, tunnel lengths, fuel requirements and power requirements.

The booklet featuring the 28 machine illustrates the machine and gives a description. Features of the machine are explained, operation information given and machine requirements and specifications listed.

Ferro Enamel Corporation, Cleveland, Ohio, has published a bulletin, "Technical Bulletin No. 7, A Study of the Free Silica in Dusts Common to the Porcelain Enamel Industry."

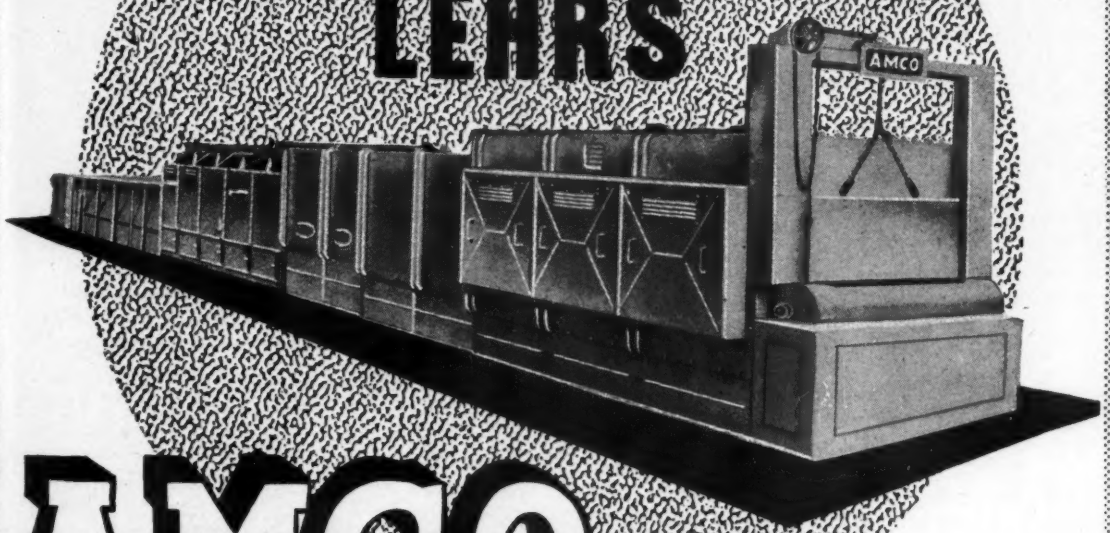
The bulletin is the cooperative work of Dr. Eric Arnold of Case Institute of Technology and consultant for the Ferro Research Staff and Mr. Russell Frank, Safety Engineer for the company. It is believed the data and methods reported will be of exceptional value to safety engineers in the ceramic industries in solving plant dust problems.

The Bristol Company, Waterbury 91, Conn., has issued a new general catalogue entitled, "Specification Index for Bristol Instruments."

The catalogue, No. W1815, contains twenty-four pages of information on the Bristol line of automatic controlling, recording and indicating instruments for use in industry and gives hints on how they can be used effectively to save time and money and promote efficient operation in manufacturing processes.

Specification data is given on each instrument listed and the booklet is illustrated with line drawings which show basic methods of applying various types of industrial instruments.

Electric
GLASS ANNEALING LEHRS



AMCO

Electrical Melting and Annealing Furnaces

The picture above shows a 1948 AMCO electrically heated annealing lehr conveyer belt width 48″ x 85′ long . .

AMSLER MORTON CORPORATION
Chamber Commerce Bldg. Pittsburgh 19, Pa. U. S. A.

AM CORPORATION

CHANGES IN CANADIAN GLASS IMPORT RULING

It is apparent that the Canadian Government has been pressed strongly to lift some of its import restrictions against American as well as other goods and one of the most important relaxations of these restrictions is contained in its latest rearrangement of glassware articles which can enter Canada, with this being of major interest to the American glass industry.

Under this change, glassware items may be brought into the Canadian market now under certain conditions from the United Kingdom and various other sources, including Czechoslovakia, Belgium, France, Sweden, Italy, etc.

P.C.4678 provided that three principal items of trade could not come into the Canadian market and these involved glass tableware; glass jars, bottles, demijohns, etc.; glassware not otherwise provided for. However, under the new and latest order, only Customs item Ex 326(i), described as "decanters and machine-made tumblers or glass not cut or decorated, not otherwise provided" is now banned. In addition, Customs item 326(ii), opal glassware, glass tableware, cut glassware and illuminating glassware, not otherwise provided, is now put on the Group IV(42%) quota list. Item Ex 326(a), formerly banned, is removed entirely from control or restrictions, with this item covering "manufactures of glass not otherwise provided."

Imports into the Canadian market of these items aforementioned had totalled $7.8 millions in the first nine months of 1947 in the case of all countries and approximately $9 millions in the whole of 1946, according to the latest information here, with such imports from the United States alone having amounted to $6¾ millions in the first nine months of 1947 and approximately $1 million from all other sources, though in 1946 about $600,000 was the amount of such imports from all countries and the balance came from the United States. In the first nine months of 1947, such imports from Britain amounted to about $250,000 and over $300,000 for 1946; from Belgium almost $250,000 in the first nine months of 1947; from Czechoslovakia about $400,000 in the same period of 1947 as well as about $125,000 from France and Sweden.

O-I ACQUIRES STOCK OF SHARPE, INC.

The Owens-Illinois Glass Company has acquired the entire capital stock of Sharpe, Inc., Buffalo, New York, in an exchange for common shares of Owens-Illinois, it has been announced.

Sharpe, Inc., does not manufacture glassware, but is one of the leading houses in the cutting and polishing of table glassware. The company has developed numerous methods of cutting fine crystal and is well known in the retail field for its attractive and popular stemware items. Owens-Illinois plans continued development of the facilities of Sharpe.

The purchase unites one of the nation's oldest and best known manufacturers of table glassware and the outstanding cutting house. Libbey Glass Division of Owens-Illinois Glass Company, founded in 1818, is known for its handmade table glassware and decorated tumblers.

R. W. Rogers, former Libbey Sales Manager, will join the new subsidiary as Vice President and General Manager.

GLASS TECHNICAL SERVICES FORMED IN ENGLAND

Glass Technical Services, Ltd., has been formed for the purpose of providing independent advisory services on all matters relating to the manufacture and use of glass, including materials, equipment, operating processes, design, administration and patents.

Its activities are intended to supplement, and not to compete with, existing agencies, and it will advocate and support those cooperative research and technical organizations which have done and are doing valuable work in building up the glass industry.

The Directors of the organization are Edward Meigh and Professor W. E. S. Turner. The new organization is located at High Holborn House, 52-54 High Holborn, London, W.C.1.

A.G.A. SPRING CONFERENCE

The annual American Gas Association Sales Conference on Industrial and Commercial Gas will be held this year in Windsor, Ontario, Canada, April 7, 8 and 9, according to a recent announcement.

Following last year's pattern, the three-day Conference will be divided to cover different phases of the gas industry. The first day will be given over entirely to industrial gas subjects. On April 8, the morning and afternoon sessions will cover subjects of general interest to all gas men; the formal luncheon will take place on that day. April 9, only commercial gas subjects will be discussed by the speakers.

Tentative plans call for some committee meetings during the Conference which will be arranged so that they will not interfere with attendance at sessions.

SCIENTIST DISCUSSES DIFFRACTION GRATINGS FOR SPECTROGRAPHIC ANALYSIS

Increasing importance of diffraction gratings for spectrographic analysis as a substitute for prisms of optical quartz which is virtually unobtainable today was the subject of a talk given before the Society of Applied Spectroscopists. The speaker was David Richardson, Bausch & Lomb Optical Company scientist and former Massachusetts Institute of Technology physicist.

Mr. Richardson discussed some of the problems involved in ruling gratings. Diffraction gratings are small optical surfaces ruled with 15,000 straight, parallel lines per inch. For proper performance, each line of the gratings must be accurate to better than one-millionth of an inch, a problem which has attracted the attention of physicists for more than a century.

Mr. Richardson illustrated his lecture with photographs of rulings engines and photomicrographs of grating surfaces. A description of the outstanding features of some of the ruling engines now in use in laboratories throughout the country was followed by a discussion of operating techniques required to obtain the necessary one-millionth of an inch accuracy, emphasizing the shaping of diamonds used for ruling.

• The Pennsylvania Salt Manufacturing Company has announced that it will build a new fluorine chemicals plant near Paducah, Kentucky. The new plant will fill Pennsalt's requirements for additional facilities for its expanding production of fluorine chemical products. Construction will be started in the near future and the first unit of the plant is expected to be completed by February, 1949.

IS USED IN THE PRODUCTION OF

DIAMOND PRODUCTS

Salt, in the form of brine, is pumped from company wells in huge quantities that exceed the hundreds of thousands of tons consumed annually by the homes of America. This enormous amount of salt—with thousands of tons of coal and limestone—and millions of gallons of water—is constantly being converted into alkalies and heavy chemicals, to meet the ever-increasing demands of industry for Diamond Quality Products.

SODA ASH
CAUSTIC SODA
BICARBONATE OF SODA
SILICATE OF SODA
LIQUID CHLORINE
CARBON TETRACHLORIDE
CALCIUM CARBONATES
SPECIAL ALKALIES

ELECTRIC MELTING OF GLASS . . .
(*Continued from page* 72)

electrodes. Two convections or turbulances are started as indicated by the arrowed circles.

The clear heavy glass will flow along the furnace bottom through the throat into the next chamber. Most of the time the glass will be perfectly clear and free from seed, when it leaves the melting chamber. The Northwestern Glass tank has worked both with and without a clearing section.

Operating without a clearing section presents, however, the danger of uncertainty. The glass may be the best glass ever made and a good run may continue for several months or more. Then the turbulance for one of many reasons intensifies and a bad run is at hand. The length of such a bad run depends to a great deal on how well the operator has sized up the situation in the first place and how much he is willing to pay for its correction. Two to three days idling of the tank and a gradual slow resumption usually does the trick. Fighting through without stopping can be done but it may take many weeks before the aggravated condition is eliminated.

With a definite clearing section as shown in drawing 17-201 control is much simpler. The clearing section is equipped with a dual heating system, electric and oil fire. High surface heat can be obtained quickly, which will cause the glass from the melting section to rise to the surface. Its seeds will expand and leave the glass, while heavy gravity glass descends and moves into the nose end.

Except for the melting section, the tank as shown in the drawing will have a life of at least 50 to 60 months. The melting chamber will only last a third as long. The use of the first bridge wall allows independent relining of the melting chamber, while the rest of the tank is maintained with molten glass ready to resume operation.

A separate drain hole should be provided for in the melting chamber. Relining is accomplished rapidly by freezing the first throat and draining the melting chamber. The electrode arrangements are removed, assembled. The vertical side walls replaced as soon as the old blocks are cool enough to handle. The whole operation including preheating and relining ought to be completed within 10 or 12 days.

For a 30-ton tank the cost of such repair does not exceed $5,400 or about 45 cents per ton glass produced. Saving in production days alone should more than pay for the relining.

The electrical installation for the furnace consists of 3-500 KVA transformers, each having voltage control by tap changing on the high tension side. Two transformers operate in series on the low tension side for the melting chamber. The other transformer operates independently for the clearing section.

Raw Material

All raw materials ordinarily used in glass making can also be used where electric melting is employed. The electric tank having hardly any volatization loss will naturally be more sensitive to selenium and other similar chemicals.

The batch should be as dry as possible. Every per cent of water in the batch will use up 8 KWH per ton glass batch, besides causing the batch blanket to cake over the melting chamber.

Electrical Controls

The electrical controls are very few: A voltmeter and an ammeter for each section of the furnace; trip and closing buttons for the breaker; and a voltage tap changer trip for each transformer.

Temperatures are forgotten as far as the melting is concerned. The electrical conductivity is in direct relation to temperature. "K" or amperes-over-volt gives the heat condition in the glass body more accurately than any pyrometer.

The tank men write an hourly record for all electrical indicating instruments. No graphic recording should be used unless automatic controls are installed at the same time. Such controls can be set either for constant power or for constant current.

Tank men for the electric furnace require no special skill.

Economy of Electric Melting

Electric power in hydro areas can now be obtained at prices below 0.4 cent per KWH. The following calculations are based on a higher power price in order to show feasability of electric melting for almost any location.

The following two sets of calculations are made, a) All electric melting, and b) Oil-Electric melting. In the calculations are also included 125 KWH of electric power per ton glass for compressors and general use in the glass plant. Charges for such power is commonly around 1.5 cents per KWH.

a) *All electric melting.* Electric power should be obtainable in most places at 0.5 cent per KWH on a 100 per cent load factor. Most glass plants operate on 92 per cent load factor. The actual price per KWH then rises to 0.545 cent per KWH. Electric energy cost per ton glass will then be:

$0.00545 \times (950 \text{ Kwh} + 125 \text{ kwh}) = \$5.85$ per ton glass. Oil at $1.80 per barrel and 1.5 barrels per ton of glass will cost $2.70 plus 125 kwh at 1.5 cents per kwh. Total cost of oil fire and electric power will then be:

$2.70 — 125 kwh $\times$ $0.015 — $4.58 per ton glass; the additional cost for electric melting totals $1.27 per ton of glass.

In all plants using both oil fired and electric tanks the reports show a consistently higher percentage of packed glass from the bottles produced from an electric furnace. Consumers even report lesser breakage of electric bottles in the pasteurizing machines. Two per cent higher pack at the electric furnace would more than compensate for the $1.27 higher cost of melting.

In many cases an electric tank is desired as an auxiliary to a larger oil fired tank, assuming such a plant is making 75 tons per day by oil and 25 tons by electricity. Giving the electric tank all the credit for price reduction on electric power used generally in the plant, the cost of electric melting per ton of glass will be:

$$\frac{25 \times 950 \ \$0.00545 - 100 \times 125 \times (\$0.015 - \$0.00545)}{25 \text{ tons}} - \$0.49$$

As seen from above, the auxiliary electric tank reduces the price of electric power generally to such an exten

(*Continued on page* 98)

New Orleans welcomes the glass industries

The Foreign Trade Zone speeds commerce and facilitates international trade.

International Trade Mart, where the products of the world are displayed for wholesale trading.

LET US SEND YOU FREE . . .

a copy of our recently completed study, "The Opportunity for the MANUFACTURE of GLASS PRODUCTS in the City of New Orleans." Write:

GREATER NEW ORLEANS, INC.,
1024 Maison Blanche Bldg., New Orleans 16, La.

. . . Means More PROFITS for YOU!

MARKETS MEAN PROFITS! . . . Here, your plant is situated *midway* between the eager domestic and foreign markets . . . at home, the vast Mississippi Valley and 10 progressive southern states and New Orleans itself, with its many breweries, bottling and food products plants, *which import glass products from at least 200 miles away!* . . . and below us, millions of dollars of glass exports each year go to Mexico, the Caribbean and Latin America, many countries of which have no glass manufacturing facilities of their own.

RESOURCES MEAN PROFITS! . . . Unlimited low cost *Natural Gas* from wells near the city permits unrestricted use of this ideal fuel . . . *Sand* that is almost 100% silicate, in limitless quantities from two ancient sea terraces 50 miles away . . . *Soda Ash* from Baton Rouge, 90 miles up the river, and Lake Charles, 175 miles away, and *Limestone* in quantity, 250 miles northwest of New Orleans and from southern Alabama. All these sources of supply are served by money-saving barge transport and by rail.

TRANSPORTATION MEANS PROFITS! . . . From the large, sheltered harbor 97 ship and barge lines send deep-draft vessels to the seaports of the world, and modern barges inland economically over a 15,000 mile waterways system. Nine trunk line railroads converge here, and 8 major air lines, 24 motor freight lines. Besides these essentials for industrial profit, New Orleans offers the unequalled trade facilities presented by International House, International Trade Mart and the Foreign Trade Zone. The supply of *Skilled Labor* has more than doubled since 1940, and *Friendly Taxation,* local and state, encourages industrial growth. Investigate now.

GREATER NEW ORLEANS

MARKETS TRANSPORT RESOURCES

ELECTRIC MELTING OF GLASS . . .

(*Continued from page* 96)

that a melting profit of $2.50 per ton glass is produced in the electric tank is obtained.

b) *Oil-Electric melting.* The oil-electric melting presents aspects which really puts the question of cost of electricity entirely in the background. Here are but a few of the important advantages of this system:

1) The auxiliary electric system will increase the production of an oil or gas fired tank by at least 30 per cent. The value of the extra production is so great that the cost of electric power becomes insignificant.

2) The combined combustion and electric heating will cut down the number of starting up days and consequently increase the operation with the same number of days.

3) Combustion may be kept constantly at its best yield point (lbs. of glass/lbs. of oil) by varying the electric input according to production.

4) Increase tank efficiency by better control of the temperature of the body of glass in the tank.

5) Elimination of streaks and cords in the glass by control of temperature and convection in the tank as in case of the all electric furnace.

Assuming an oil fired tank of 90 tons original capacity, being increased to 120 tons by an auxiliary electric heating system, the electric heating will be almost 100 per cent efficient as the combustion already has taken care of the tank radiation losses. The electric melting will, therefore, only require about 700 kwh per ton glass. If at the same time, a good wholesale power contract is obtained, the combined heating will be extremely cheap.

Negotiations for Electric Power

In negotiations with respective power companies, it is necessary to stress the unbelievable high load factor for glass plants in general even without electric melting. Before signing any new contract with the power company, it is advisable to request a complete graphic study of all electric services in the glass plant.

In Conclusion

The electric glass tank will greatly influence the designs and even the locations of the glass plants of tomorrow, particularly as unit furnaces with flexible production facilities can be established close to the markets.

A SCALE OF ACIDITY AND BASICITY IN GLASS . . .

(*Continued from page* 74)

nents in glass. It is natural that the list could be used as the scale of acid and base without any serious objection. The list with some modification is reproduced in Table I (see page 74).

In the Table, the acids are at the top, as it descends on the Table, the strength of acid decreases. Conversely, the bases are at the bottom of the Table, and its strength decreases as it ascends on the list. For any component, it will behave as a base with respect to all other components above it on the Table, and as an acid with all those below it. As one would expect, Cs_2O is the strongest base or the weakest acid among all. It is interesting to note that B_2O_3 is the strongest acid, a fact which should be familiar to the glass chemist, yet quite astonishing to chemists in other fields. The position of B_2O_3 in ordinary borosilicate glasses is obtained by assuming that 20 per cent of B is in the state of coordination 4. An unpublished investigation by the author reveals that only about 20 per cent of total boron atoms take 4-fold coordination, even if there are abundant of oxygen atoms in glass for all boron to change to 4-fold coordination. The acid strength as well as the bond strength depends on the coordination number. For the same oxide, the higher the coordination number, the weaker the acid or the bond. This is clearly shown in the case of B_2O_3, Al_2O_3, etc., in Table I. The order of oxides in Table I is subjected to change if the coordination number in glass is found different from that adopted. The positions of GeO_2, BaO, and V_2O_5 are altered slightly, because the thermal data from which the present scale was derived may be in error large enough to allow for the alteration, which is made from theoretical considerations and practical experiences. The acid strength or the bond strength for P_2O_5, V_2O_5, and As_2O_5 are derived by dividing the dissociation energy of one-half "mole" of these oxides by 5 instead of 4, because one of the four oxygens surrounding the positive atoms (P, V or As) behaves very much like a double bond. For the first approximation, one double bond is assumed to be equivalent to two single bonds. The values obtained by dividing the dissociation energy by 4 are also given as the upper limit for these oxides. The division into glassformers, intermediates, and modifiers for the acidity scale is arbitrary and is given only for the convenience of readers familiar with glass technology.

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GLASS BLOCK ALLOTMENTS DISCONTINUED

A forced allotment program that has governed the shipment of glass blocks for the past two years has been discontinued as of January 1, 1948, it was announced by H. R. Haynes, Sales Manager of Pittsburgh Corning Corporation.

Pittsburgh Corning's new glass block plant in Sedalia, Missouri, now in full operation, will double the production of blocks. "After January 1," Mr. Haynes concluded, "there will be no restrictions on the quantities or sizes of standard blocks that may be ordered."

GREETINGS TO AMERICAN GLASS INDUSTRY FROM CZECHOSLOVAKIA

A communication has recently been received from Dr. V. Ctyroky, Director of the Glass Research Institute of Dr. Edvard Benes, Hradec Kralove, Czechoslovakia, extending greetings to American glass technologists for "A happy and prosperous New Year and hoping for better and happier times to come."

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STATISTICAL CONTROL . . .
(*Continued from page* 80)

hydrostatic pressure, temperature shock, and polariscopic examination.

The method can be illustrated by the use of the sampling tool statisticians call a bead-sampling box. It consists merely of a collection of colored beads, substantially alike in shape and weight, in which the proportion of beads of different colors can be altered to have any desired relationship. Paddles having recesses to catch and hold the beads are used to select the sample by dipping the paddle into the beads in such a manner as to fill all the recesses. By counting the beads according to color, one can compare the result with the known proportion. It is usual to employ a thousand or more beads, and remove fifty or less at a time by way of a random sample, returning these beads to the main group after each sampling trial.

We can set up such a bead box easily and quickly in order to illustrate random sampling. As an example 4% of the beads can be red, the remaining 96% yellow, in order to illustrate a system containing 4% defectives. We can sample this population 50 beads at a time, with replacement each time, using a paddle having that many recesses. In so doing we would expect an average of two red beads in each group of 50, but experience proves that we actually get considerable variation. What we are doing in this experiment is to show what might happen if we took a sample of fifty as a means of estimating the proportion of red and yellow beads in a lot (or shipment) of 1000 beads.

TABLE I

Results of Random Sampling, by 50's, of a Population Containing 4% Red Beads, 96% Yellow Beads

Lot No.	No. of Red Beads	Lot No.	No. of Red Beads	Lot No.	No. of Red Beads
1	1	9	1	17	3
2	5	10	2	18	1
3	2	11	1	19	4
4	1	12	0	20	2
5	2	13	3	Total red beads	41
6	2	14	1	Total beads sampled	1000
7	4	15	0	Fraction red beads	.041
8	3	16	3		

(Note that the net result is not the 4% red beads actually in the box. The result obtained by sampling is not necessarily the true value—it may be larger or smaller than the true value and the variation will depend both on chance and on the conditions of sampling. If sampling had stopped at the 18th sample, the answer would have been 3.9%; if stopped at the 16th sample, it would have been 3.6%; if at the 14th sample, it would have been exactly 4.0%. If only the seventh and eighth samples had been taken, one would say that the box contained 7% beads; the eleventh and twelfth samples taken above would have indicated only 1% red beads. Thus, even when we know the true proportion of red beads, random sampling variations will lead us to mistakes in judgment unless we realize that such variations occur, and accept a limit of variation that meets our needs.)

Table I shows the result of 20 such samplings. Inspection shows a fair number of 2's, but also such variations as 0 and 5.

Here is illustrated the principal point of this discussion. When all possible causes of variation are removed except those of pure chance, there still will be instances when *no defectives* will be found in a sample that should average two per sample, or when *two and one-half times the true proportion* of defectives will be found. No one can safely set a standard, with whose compliance determination is made by sampling means, so close as to exclude all values only a fraction worse than that desired to be accepted.

How are we to get order out of the confusion of values shown in this table. Is it usual to get such variation?

First let us examine the variation to see if it can be considered "normal," mathematically. To do this we use the binomial distribution obtained by expanding the binomial $(Q+P)^n$, where:

P = the fraction defective
Q = the fraction effective, or $(1-P)$
n = the number of items in each sample

$$(Q+P)^n = Qn + nQ^{n-1}P + \frac{n(n-1)}{2!}Q^{n-2}P^2 + \frac{n(n-1)(n-2)}{3!}Q^{n-3}p^3 \ldots \text{etc.}$$

It so happens that each of the terms of this binomial has a relation to our sampling. The first term, Q^n, gives the proportion of times zero will come up as the number of defectives in a sample of n pieces. The second term, $nQ^{n-1}P$, gives the proportion of times *one* will come up as the number of defectives in a sample of n pieces, and so on. Comparisons are made in Table II, showing the conditions when $P = .04$, $Q = .96$ and $n = 50$, which were those actually providing the data in Table I.

When applied to this particular sampling problem the formula becomes:

$$(.96 + .04)^{50}$$

The first term of the expanded binomial is $(.96)^{50}$, or .1299. The second term is $50(.96)^{49}(.04)$, or .2706. These and other values are found in various texts and tables, such as in Dr. Holbrook Working's "A Guide to the Utilization of the Binomial and Poisson Distributions" (Stanford University Press), so that we need not follow the involved calculations of all of the terms of this binomial.

TABLE II

Summary of Sampling by 50's in a Population of 4% Red Beads, Sampled 20 Times and Compared With Poisson's Distribution for These Conditions

No. of Term in Binomial	No. of Red Beads in 50 Pn	Frequency of Red Beads f	Fraction of Red Beads f/m	Poisson's Distribution Values
1	0	2	.10	.1299
2	1	6	.30	.2706
3	2	5	.25	.2762
4	3	5	.20	.1842
5	4	2	.10	.0902
6	5	1	.05	.0346
7	6	0	0	.0108
8	7	0	0	.0028
9	8	0	0	.0006
10	9	0	0	.0001
		20 = m		
		= no. of times sampled		

If we had made a large number of samplings we might

(*Continued on page* 102)

2 WAYS

to approach a color problem

...grope around in the dark OR ask Drakenfeld to help

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We would like to demonstrate how our color research facilities and technical counsel can help you shed light on color problems. We hope you will avail yourself of Drakenfeld's broad experience and helpful service. Let us discuss your requirements across your desk. Write us today.

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STATISTICAL CONTROL . . .
(*Continued from page* 100)

have occasionally (according to the last column of Table II about 1% of the time) found six defectives in 50 samples. Once in about ten-thousand times we would have found nine red beads. Thus, the second question, "is this variation usual?" is answered in the affirmative.

The whole problem of tolerances can be attacked statistically. *Most tolerances are artificial and arbitrary*, without regard either to the needs of the user or the maker of the item. If they are set to what *has been shown to be needed*—not as has been described as "the smallest measurement the draftsman could think of, divided by two"—it becomes a matter of determining the frequency distribution of the product and whether the distribution can be kept commercially within the tolerance, either as made or by elimination of off-specification units. A widespread distribution, or a product whose average varies from time to time, will give trouble. A distribution well within the tolerance limits, and kept there, will give little or no trouble. Again, the statistical method becomes a tool of importance, but coupled with a knowledge of the method of manufacture, for the amount and kind of variation is a matter that is inherent in the process.

The applications of statistical methods to production have in many cases taken the form of "control" charts based on frequent examination of small samples. Frankly, we have found few applications of this method. It was valuable to many industries during the war, particularly where tolerances were close, and where it was important to avoid off-specification product, or to reject it, regardless of cost. This does not apply so strictly to our industry, where we have found natural variations setting a pattern of wide tolerances in order to enable a low-priced product to be sold. It is, however, an important integral part of the statistical method, and the student should know its applications.

I have made no attempt to describe or to explain the methods used in the so-called "statistical" or "probability" methods. It would have been impossible in thirty minutes time. I have chosen to point out that it can be applied to ceramics, just as it can apply to every industry, in so far as the handling of *measurements* are concerned. The method is not a "test" in itself, but a method of understanding the test. It is not a cure-all, but a sign-post concerning a need for a cure. It does not tell how to remedy a situation, but it does point out more quickly and surely than any other method, *that a remedy may be needed*. It is a sort of mathematical alarm clock to spur the user to action when, and only when, action is needed. It pays dividends in avoiding unnecessary action, as well as prompting action when it is necessary.

Some of you may wish to explore this method further. If you will inquire of the several universities in your area, you may learn of short courses, as at UCLA, Stanford, U of C, and others. There is an active California group in the national organization, the "American Society for Quality Control" which has offices at 305 East 43rd Street, New York 17, New York. Dr. Holbrook Working of Leland Stanford University, was one of the prime movers of the statistical method in its wartime uses, and should be able to advise of study groups in the western area.

For those who wish to study "on their own," my choice of texts would be E. L. Grant's (McGraw-Hill) "Statistical Quality Control" as an introduction, along with the booklets Z1.1, Z1.2, and Z1.3, on Control Chart Methods issued by the American Standards Association of 29 West 39th Street, New York. After these as starters come such books as Smith's (McGraw-Hill) "Elementary Statistics and Applications" or Duncan's (McGraw-Hill) "Sampling Statistics and Applications," Kenney's (Van Nostrand) "Mathematics of Statistics," Croxton and Cowden's (Prentice-Hall) "Applied General Statistics," Waugh's (McGraw-Hill) "Elements of Statistical Method" and many others. The real meat of the statistical bill of fare is to be found in Shewhart's (Van Nostrand) "Economic Control of Quality of Manufactured Product," and Simon's (John Wiley) "Engineers Manual of Statistical Methods," but they can be heavy reading until one's appetite is whetted with a beginning of the subject.

Finally, do not expect the method to do the impossible. It is a tool, whose edge is sharp or dull according to the care taken in its development. Like any other tool, the results depend on the skill of the user and his knowledge of where to apply it. Personally, I am convinced that it is a tool that must be in the possession of each research and quality man in the ceramic industry, as well as other industries, in order to make real advances in quality and its production.

BRITISH EXPANSION OF GLASSILK INDUSTRY

An important expansion of the glassilk industry in Britain, for insulation and textile purposes, is promised in plans just announced and approaching completion, by Chance Bros. Ltd., one of the largest of the British groups in the industry.

According to Sir Hugh Chance, Chairman of the company, the development is of considerable industrial importance. He stated: "The present company was started by Chance Brothers, one of the parent companies, at Glasgow in 1930 to manufacture heat and sound insulation products made from glass fibres. The business grew steadily, and in 1938 plans were laid to enter the textile field.

"During the war the output of heat insulation and textile products increased rapidly. Two new factories for textiles were set up in the Glasgow district, and a third at St. Helens, Lancs., was taken over in 1945. Sales in the textile field had already outrun production capacity, and early in the new year a large extension of the company's textile division would start operations at St. Helens and at Possilpark, Glasgow.

"The extensions to the existing factory at Possilpark are now almost completed, and the textile plant and furnaces for making the continuous filament fibres will soon be installed. On the three floors there will be a total floor space of 90,000 square feet. Planned on the most up-to-date lines, the building will be fireproofed throughout."

CORNING ESTABLISHES NEW DEPARTMENT

Corning Glass Works has announced the establishment of a Foreign Technical Service Department, according to a recent report. Dr. John F. G. Hicks will be the Director, and will assume responsibility for technical aid to Corning's foreign interests.

• WHY THEY WENT TO OKLAHOMA •

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it was 5 Favorable Factors

MR. WILLIAM C. DECKER
President
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Says:

"Last month, Corning Glass Works started to produce Pyrex brand glassware in its new plant at Muskogee, Oklahoma, where 400 Oklahomans are already employed. Before erecting this new unit, an extensive survey of other industrial areas was conducted.

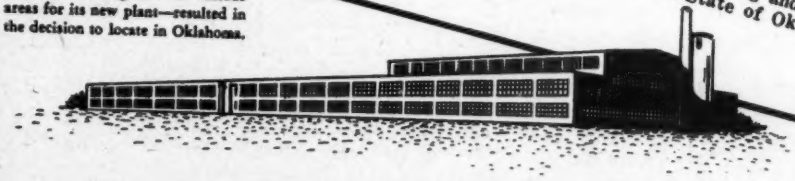
"The five factors that influenced us to locate in Oklahoma were:

- **The availability of the desired number of high-grade workers needed for the manufacture of glass.**
- **An ample and constant supply of low cost natural gas, the fuel vitally important to our manufacturing operations.**
- **A nearby supply of superior glass sand — one of our basic raw materials — and easy access to sources of other necessary supplies.**
- **The dependable electrical power service available in Oklahoma.**
- **The location of Oklahoma in relation to our markets and its excellent rail transportation facilities.**

"These reasons, as well as the friendly and cooperative interest shown by local officials and business men, lead us to anticipate a long and mutually beneficial association with the State of Oklahoma."

"CORNING *means* Research in Glass"

. . . and *industrial* research by Corning—investigation of various areas for its new plant—resulted in the decision to locate in Oklahoma.



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CONVECTION CURRENTS IN A GLASS TANK . . .

(*Continued from page* 78)

only if there is equilibrium between the heat which it gains when it is taken up with the hot current and that which it loses when it is taken up with the cold current. More generally, this equilibrium is not satisfied: the "roller" drifts sidewise; instead of turning upon itself after the manner of a barrel, it elongates after the manner of a spiral horn, whether by increasing its diameter or by diminishing it according to the thermal conditions which it encounters.

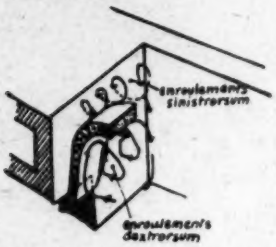


Fig. 18. Another type of rollers, right- and left-hand.

d. *Generalization concerning the rollers.* This idea of equilibrium of exchanges lengthwise of these circuits permits the general idea of "rollers." Whenever an accident impresses a sudden change of temperature upon the large general circuit, a circuit stopper is formed which assures heat exchanges across the temperature interval. This circuit stopper may bring about quite diverse forms; the Schild Rollers (clockwise in the figure) constitute only a particular case. Other examples follow.

An immersed barrier such as that which we have shown in Figure 14, or one which has brought about the corrosion lines of Figures 15 and 16, does not have any cooling effect by itself. The masonry barrier with a hollow for ventilation or for the circulation of water is, on the contrary, a cooling source. The hot glass causing the reversal releases a side stream which laps at the barrier and, being unable to redescend, rolls upon itself while it displaces laterally until it escapes upon the borders of the ascending current (Figure 18). This roller is in this case counter-clockwise.

Following a skimming doghouse, which is a small wing of exceptional cooling, analogous rollers are produced, the traces of which are clearly visible in Figure 19.

In the angles at the bottom of the tank, circuit stoppers equally tend to form, constituting, in the architectural sense of the word, "finials" of the principal movement (Figure 20). Following the mean viscosity, this auxiliary circuit is entrained after the manner of a set of gears (counter-clockwise in the figure) or drifts with a branch of the wall current (clockwise in the figure).

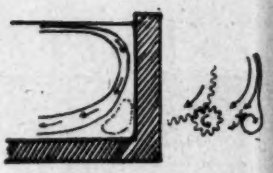


Fig. 20. Currents at a dead corner.

If the glass is too cold and too viscous, these circuits block themselves into a stagnant zone in which develop seeds of devitrification which render them quite recognizable after the furnace is cold.

In large cavities and in the joints it forms as well individual circuits of the same origin as the finial currents (dead-end currents, according to Jebsen-Marwedel).

e. *Influence of constrictions.* We consider important constrictions and not simple hindering projections on the barrier. In the case of a constriction consisting of a sharp and considerable diminution of the width of the tank over its entire depth, a triple regime has a tendency to establish itself. The intermediate cycle concerns the entire furnace; it is separated on all sides from the wall cycles which press upon the constriction (presumably cooled), as shown schematically in Figure 21.

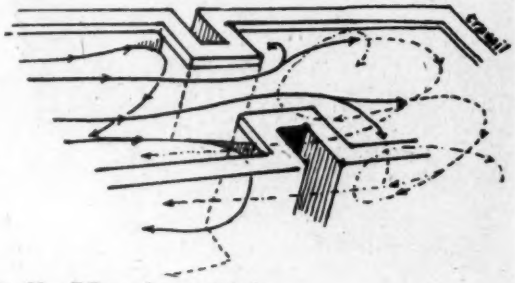


Fig. 21. Effect of a constriction.

f. *Influence of throats.* These combine the effect of lateral constriction indicated above and the effect of a deep barrier. They are efficacious in bringing about an important lowering of temperature because they check the driving-belt effect which would tend to equalize the temperatures of the melting chamber and the working chamber which are separated by the throat; and on the other hand, the direct flow through the throat is itself energetically cooled by contact with large surfaces generally air-cooled. Whereas a barrier produces a lowering of temperature of a matter of 100°, the throat brings about a cooling of the order of 150-200°. The upward shift beyond the throat provides a hot surface easily noticeable which, nevertheless, diffuses quite rapidly into the ensemble of the working chamber.

g. *Currents of composition.* Before finishing with the principal characteristics of currents in the tanks, it is necessary for us to say something of what happens in the depth before the hot source and on the walls near to the hot source.

Under the cold mass there is a descending current analogous to that which happens in the atmosphere beneath a cloud; it results in a constant suction toward the surrounding hot glass which contributes efficaciously to the fusion and especially to the immediate mixture of new glass with the old glass.

(*Continued on page* 106)

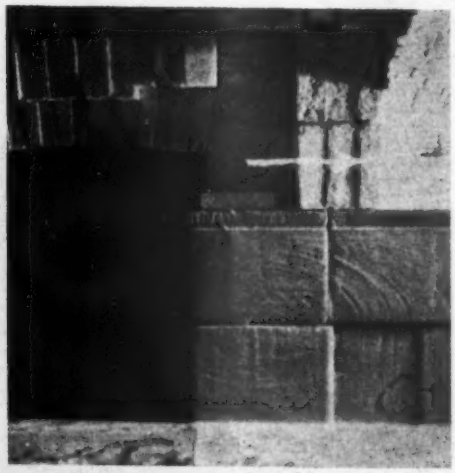
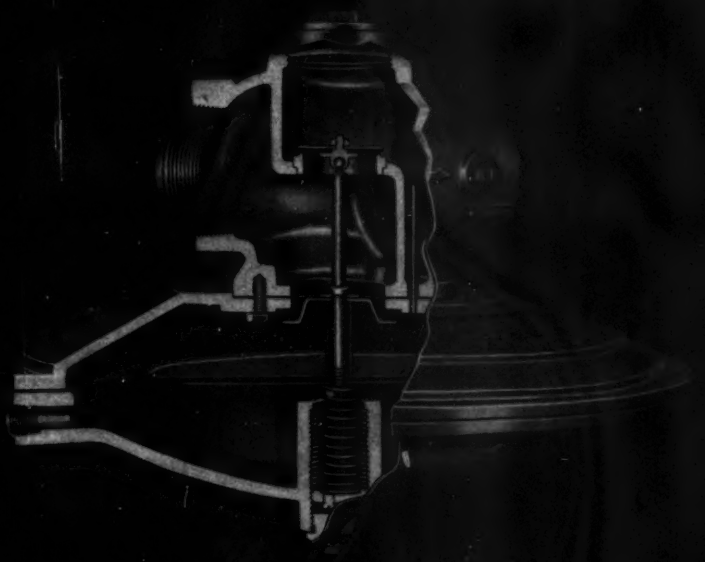


Fig. 19. Tracks of rollers following skimming.



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(*Continued from page* 104)

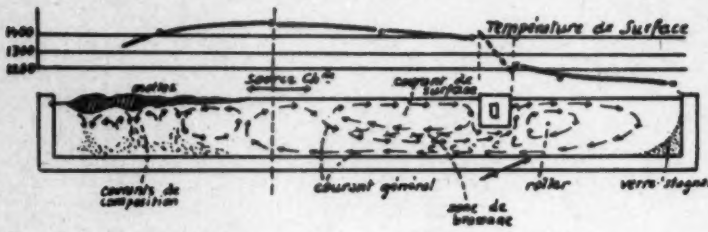

Fig. 22. An assembly figure.

h. *The hollowing out of the walls in the fusion zone.* The corrosive effect of new glass incompletely founded, and especially extremely hot, causes a great amount of wear in the uppermost part of the tank.

At contact with the flux line, the "saber cut" appears, a deep groove from which take off almost vertical scratches in deep hollowings bordering upon forms of stalactite types. Contrary to those which we observe in the colder zones where the scratches follow the general line of movements of glass observed by other direct methods, the scratches of the melting compartment do not seem to be in relation with the movement of the glass observed near the walls.

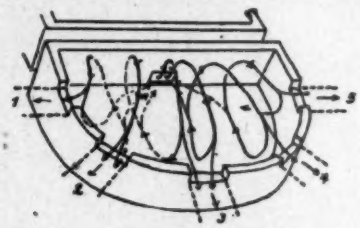

Fig. 23. Bowmaker and Cauwood spirals.

It is stated that in this zone the wall glass is loaded with alumina proceeding from the dissolved refractory. This glass is very viscous. There is in the neighborhood of the wall an actual discontinuity of viscosity of such a kind that the hot glass which is dragged in the general convective movement and which has weak viscosity, is not able to transmit to the viscous lining a force sufficient to impress a component horizontal to its displacement. The latter is accomplished under the form of a slow vertical streaming.

F. W. Preston (loc. cit.) attributes a particular influence to the periodic variations of the level, of very small amplitude, due to charging. The very aluminous glass attached to the wall at the top of the "saber-cut" is uncovered by the lowering of the level and descends under its own weight. At the time of the raising of the level it remains in place. Upon the next lowering, new glass is uncovered which descends in its turn and drives back the preceding wash.

The explanation loses a little of its value from the fact that the continued chargings actually practiced have not visibly modified the phenomena of wear.

i. *The favorable and unfavorable roles of convection currents.* Figure 22 summarizes the principal movements. It stresses their complexity. If we were entirely the masters of these currents, our glass furnaces would certainly make very great progress.

It seems that one is almost assuredly able to give to the credit of these convection currents their helpful role in the homogenization of glass. These currents are the mixers of different layers. The more intense they are, the better the quality of the glass.

Their intensity grows with the dimensions of the furnace, especially in length. The glass furnaces of quality —window glass, Pittsburgh Plate Glass—are the long furnaces of important convection.

Their intensity grows with the temperature of the fusion zone; on the one hand, because the differences of temperature between the hot and cold sources is more important, and on the other hand, because the greater fluidity of the glass permits more rapid movements.

Even the most limited furnaces functioning at a high temperature make homogeneous glass. The throat furnaces, with retarded convection, have more difficulty in making homogeneous glass. Bishop[8] has stated that glass arriving at the machines can follow different routes, the "messengers" arriving one after the other. In his furnace the first "messengers" arrived between 2½ and 4 hours after charging, but it was not until 84 hours after charging that the glass arriving at the machines contained 50% of glass less than 84 hours old. At the same time, 1% of the glass drawn contained glass less than 12 hours old.

Bowmaker and Cauwood[7] have already established the successive arrival of "messengers" at the machines. They attribute this to the spiral progress of the glass in the working chamber. Exact explanation of this is found in

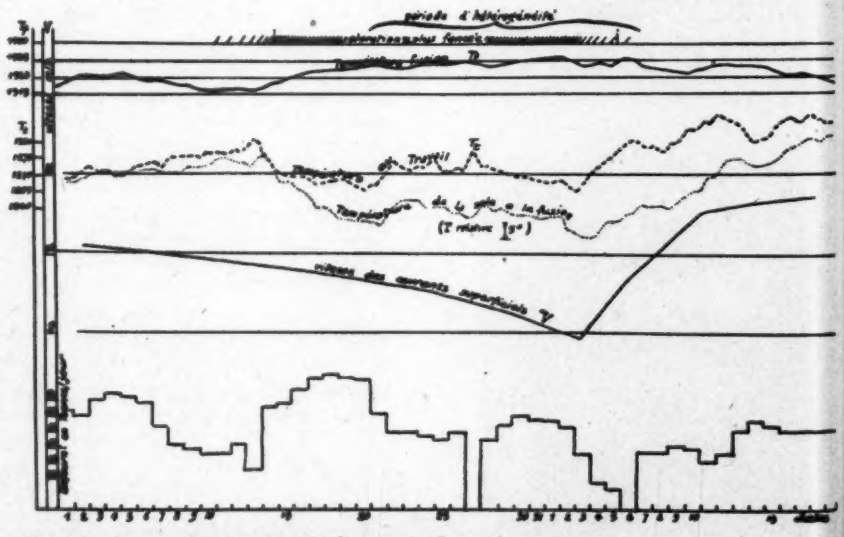

Fig. 24. Curves showing relation between color and currents.
Coloration plus foucee = deepest coloration.
Enfourn *t* en tounes/jour = pull in daily tons.

the condition of the successive spirals which do not transport the same glass travelling as one body, but are formed from the side streams as shown in Figure 23.

All this indicates the interest there would be in knowing how to design in a sure way a furnace form regulating the currents so as to obtain a rapid mixture of the different glass layers. To the debit of convection currents, it is necessary first to mention the hindrances encountered following the change of pace of a furnace—or composition—which often give rise to a modification in the distribution of temperatures. Some stabilized glass in certain local circuits is found to be taken up again in the principal circuit, introducing some of the heterogeneities. Some of the zones where devitrified glass becomes stagnant are reached by the new regime, and release their stones.

The table of curves above (Figure 24) illustrates very well the preceding material. It involves a plate glass furnace in which, temporarily, increased iron content is introduced. The permeability of the bath is varied. At constant operation of the furnace, the surface temperature is raised and the bottom temperature is lowered. *The ensemble of convection currents has diminished.* (See the third part, on the role of diathermancy.) Very quickly "ream" is apparent in the sheet, a sign of the heterogeneity of the glass. The clearing of the tint entails a reheating at depth, the increasing of convection currents, and in parallel, the increasing of the homogeneity and quality of the glass.

Likewise, to be charged against convection currents is the severe wear set up in the zones of high speed: the throat cover, a barrier, and a doghouse.

But one of the most curious aspects of convection currents is their role in distributing the heat. As soon as one tries to accumulate heat in any point whatever in the furnace, some currents are produced which are bound to disperse heat toward the cooler zones; the result of this is that the "melt" is not hot enough even when the furnace is hard-driven. Most of the heat of the highest thermal potential (a quality which, as one knows, is most effective), laboriously transmitted to the hot source of Gelhoff, will degenerate in the length of the convective circuit and definitely serve to compensate the losses of the cold compartment; so that it is sometimes necessary to lower, by external means such as ventilation, the temperature of the glass which arrives in the working compartment, and that to the detriment of the furnace yield.

The successful furnace is one which is able to equalize the debit and credit: sufficient convection currents to produce glass well mixed and well homogenized; and sufficiently small currents, so that they will not too readily transport an overheated glass to the machines. It ought to be possible to heat the working compartment of a furnace, the losses incident to the perceptible heat of the drawn glass being restored during the "furnacing." As an alternative, let the drawing compartments have wide openings because the glass is too hot for working.

We will show, in an important notation in the third part, upon what tangible plans it is preferable to act, in order to obtain a good working temperature, and how, in a certain measure, one can overcome convection without harming the quality of the glass.

(*To be continued*)

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When included as a minor constituent in the container batch formula will justify its addition in improvements in the melting, fining, and forming operations as well as impart beneficial properties to the finished container.

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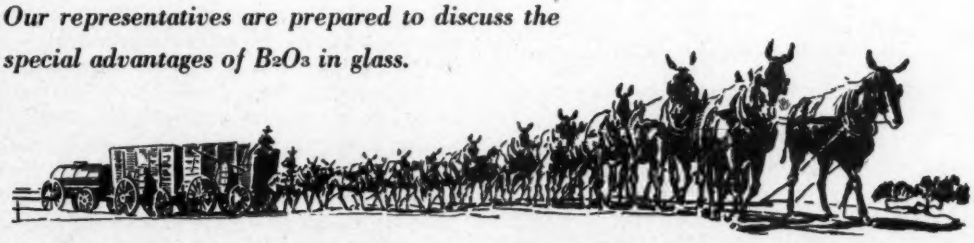

PACIFIC COAST BORAX COMPANY

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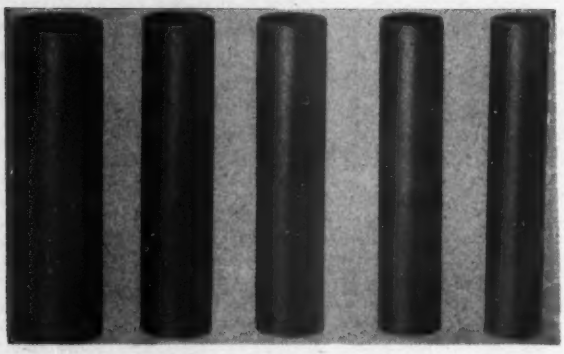
GUNITE



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Gunite can be machined with relative ease, yet has a high density that will take a brilliant polish. Round Bar Stock is available in 18 sizes from ¾" to 5" diameter, all bars 14" long. There is a suitable Gunite alloy for many types of glass-making castings such as Plungers, Ring Sticks, Neck Rings, Guide Rings, Moulds, Blanks, Bottom Plates, etc.

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NATURAL GAS OUTLOOK . . .
(*Continued from page* 82)

of years reserves would last at the 1946 constant rate of removal.

As to the future reserve picture, many geologists believe that the present proven reserves are only a fraction of the total reserves. Potential reserves, yet to be discovered, include the natural gas to be found by deeper drilling in present producing fields, to be found in extension of present fields and to be found in new fields in regions now producing, as well as regions not now producing.

It therefore seems evident that there are adequate supplies of natural gas for many years to come. At present, there is definitely no shortage of natural gas in this country.

The problem confronting the gas industry is to provide the connecting link between this tremendous gas supply and the points of market requirement, in adequate amounts and at reasonable prices. In recent years, many long distance transmission lines extending from the Southwest—Eastward, Northward and Westward—have been built and tremendous volumes of gas have become available to remote areas never before having had this service. Release No. 3459 (G-1141) of the Federal Power Commission shows the rapidity with which expansion is taking place on these long distance transmission lines, as follows: "Construction and operation of new facilities to increase the capacity of the nation's natural gas pipe line systems by nearly 2 billion cubic feet per day, were authorized by the Federal Power Commission during the 12-month period from July 1, 1946 to June 30, 1947," Chairman Nelson Lee Smith announced. "Cost of the facilities authorized was estimated at $273,190,302, of which an estimated $257,448,776 was for projects, each costing $700,000 or more. These larger projects were planned to benefit nearly 80 major cities and numerous smaller communities in 20 states, many of them in the Appalachian and midwestern areas, where gas shortages have been prevalent. The unprecedented postwar activity in the natural gas industry has continued during the past in even greater measure than between July 1, 1945 and June 30, 1946, when the Commission authorized construction amounting to $127,189,731. Over twice as much was authorized this year and last year's record was outstanding in the history of the Commission."

Because of the tremendous financial outlay to build, these lines must operate at a very high load factor, if gas is to be sold in the market areas at reasonable prices. This is indeed a problem, when one considers the tremendous fluctuation in market requirements between summer and winter. As one means of accomplishing this purpose, many utilities located in former gas producing areas, which are now exhausted, have developed underground storage in these areas and during the lean summer months, the surplus gas available through these lines over summer requirements is pumped back into the ground. As this process is carried out during the summer, tremendous volumes of gas in these underground areas are available for the excess winter requirements, which requirements are in excess of the capacity of the pipe lines. These tremendous holders of gas, adjacent to markets, assist very materially in helping supply the winter peaks, as well as make possible a good load factor

on the long distance transmission lines, and which results in economical rates for gas.

Many utilities have added further to their facilities for providing additional supplies of gas by the installation of liquid petroleum stand-by plants to augment the supply of gas in cold weather. This is similar to the installation made by many of the glass industries, but on a much larger scale.

Another possible source of fuel to augment the heavy winter requirements of utilities is the new joint experimental process of the Pittsburgh Consolidated Coal Company in collaboration with the Standard Oil Development Company, which are now building a pilot plant for the production of gasoline and gas of high calorific value from coal. This plant, located at the mines, will produce gasoline during the summer months, and high B.t.u. gas during the winter months. Just what the economics will be in comparison with competitive fuels is yet to be determined.

It appears that in the near future, there are ample supplies of natural gas to meet requirements and every effort is being expended by the many gas utilities to make these supplies available in the market areas just as soon as possible. The gas industry will improve its services in the next few years to the point it had when it secured such a high confidence from the people and industries it served.

INVENTIONS AND INVENTORS . . .
(*Continued from page* 87)

octadecylamine acetate and 0.1 lb. pine oil and then subjected to froth-flotation. The result was then conditioned for about 15 seconds in an aqueous pulp contining about 10% solids, with 1.6 lbs. sulfuric acid and 0.2 lb. pine oil, each per ton of solids in the pulp. After froth-flotation and other treatment, the sand contained only about 0.028% Fe_2O_3.

The following references are of record in the file of this patent: United States Patents: 2,205,503, Trottier, June 25, 1940; 2,340,580, Cole, Feb. 1, 1944; and 2,173,909, Kritchevsky, Sept. 26, 1939.

PENNSALT APPOINTMENTS

James McWhirter has been placed in charge of Fluorine Product Process Development and Manufacture for the Pennsylvania Salt Mfg. Company, it has recently been announced.

Mr. McWhirter, Superintendent of the company's Natrona, Pa., plant for the past two years, will direct all phases of the company's growing activities in fluorine product manufacturing. Prior to joining Pennsalt as a chemical engineer in 1945, Mr. McWhirter had been superintendent of plants in Detroit and Cleveland for the General Chemical Company.

Albert H. Clem has also been appointed to a newly-created position as Field Sales Supervisor. Mr. Clem will supervise activities of the District Sales Managers and all field men of the Division.

A graduate of the Pennsylvania State College with a degree in chemical engineering, Mr. Clem has been with Pennsalt since 1938 when he became Detroit sales representative.

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PROTECTION

You breathe pure, dust-free air in a batch room equipped with Smith Glass Batch Mixers. That's because the Smith is *dust-sealed during the entire cycle of operations* — charging, mixing and discharging. There's no chance for dust to escape. Practically eliminates the dreaded silicosis hazard. Promotes employee health and efficiency, at the same time producing quality glass batches in the shortest possible mixing period.

New 40 cu. ft. Smith Glass Batch Mixer equipped with dust boot which confines dust within mixer drum.

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Glass Batch MIXERS

"Best Available Plant Engineers Consulted"

When the Foster-Forbes Glass Company contemplated the construction of a new batch-mixing plant, the best available plant engineers were consulted, including those of The Neff & Fry Company.

The plant consists of nine N. & F. concrete stave silos with conveyors, feeders, mixers, etc. Seven of the silos are 60 ft. high, 16 to 25 ft. diameter; two are 45 ft. high x 12 ft. dia. Each silo has capacity for a 21 days' supply of a certain material.

This is cited as an example of silo installations which are continuously on the agenda of our company. If you have a project for storing and handling flowable bulk materials of any kind, it will pay you to get complete information from us.

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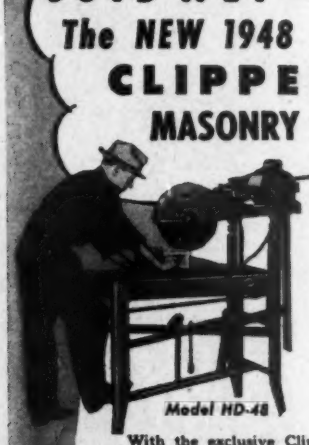

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EDMUND BALL NAMED PRESIDENT OF BALL BROTHERS

It has recently been announced that Edmund F. Ball has been named President of Ball Brothers Company to succeed his uncle, George A. Ball, who will continue to serve the firm as Chairman of its Board of Directors.

The new President of the company has been serving as Executive Vice President of the company since 1945, shortly after his return from service in World War II. He is the third president of the company since its start in 1878, and is the son of the late Edmund B. Ball, the first Vice President of the company and one of its founders.

BAUSCH & LOMB TO OPEN CANADIAN PLANT

Bausch & Lomb Optical Co., Rochester and Toronto, expect approval under the Canadian Government's import restrictions laws to bring into Canada American process equipment already under manufacture for its proposed new optical lens plant at Midland, Ont., Canada, with the belief that a start on the construction will be made next spring.

The company's first Canadian plant will provide 12,800 square feet at an estimated total cost of $200,000 for the building and equipment.

Provision is being made in the plans for three 10,000 square feet additions at two-year intervals if experience warrants such expansion. The initial unit, scheduled for fall completion, will employ about 60 making ophthalmic lenses, single and bifocal, for domestic and export markets.

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COLOR MICROSCOPY PROCESS SPEEDS IDENTIFICATION OF MATERIALS

Microscopy in color without the use of dyes or light filters is now a reality, according to a report by Bausch & Lomb Optical Company. The new microscopy technique, developed by German C. Crossmon, Bausch & Lomb scientist, provides a speedier, more accurate identification of a wide range of colorless, transparent substances, including drugs and minerals.

In a recent talk delivered by Mr. Crossmon, he termed the technique "dispersion staining" and showed color photographs of thin sections of body tissue in which muscle fiber, blood vessels and fatty tissues appeared in bright contrasting colors.

Mr. Crossmon demonstrated that only standard microscope equipment is required to turn transparent, colorless objects to bright colors. By choice of the correct immersion liquid which is placed over the sample, each different material appeared a different color. He further illustrated his technique with photographs of textile fibers, grains of glass and mixtures of minerals. In each case, particles of different composition were different in color.

The apparent magic by which white light on a colorless object produces color has a sound scientific explanation, Mr. Crossmon pointed out. The light from the microscope lamp is passed through a dark-field substage lens to strike the sample at a high angle. The sample is covered with a high dispersion liquid that matches the light-bending ability of different materials in the sample at different portions of the color spectrum. Each material then scatters some of the colors present in the white light into the microscope where they are seen by the observer while other colors pass directly through the sample at such a high angle that they do not enter the microscope.

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LEHR FOR SALE—6'-0" wide muffle lehr designed for oil or natural gas firing. In excellent condition. Used for one month. Ideal for tableware and miscellaneous production. Will dismantle and re-erect. Available immediately. Reply Box 70, c/o The Glass Industry, 55 West 42nd Street, New York 18, New York.

1—36 inch Velte Air Reversing Valve, in good condition. Carr-Lowery Glass Company, Baltimore 3, Maryland.

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WANTED IMMEDIATELY — Superintendent and shift foremen for factory in Venezuela. Plant equipped with Hartford-Empire feeder, I.S. machines, stackers and lehrs. Contract for 2 years. Write for interview. Reply Box 71, c/o The Glass Industry, 55 West 42nd Street, New York 18, New York.

Wanted—For permanent position, experienced mold designer who can start in as an assistant and later head up a mold design department for medium-sized glass container company. Reply Box 72, c/o The Glass Industry, 55 West 42nd Street, New York 18, N. Y.

INDUSTRIAL ENGINEER with approximately 5 years' experience in methods analysis and time study practice in glassware decoratfng and finishing operations. Excellent opportunity. Reply, giving resume of experience, education, recent photograph and references. All information held strictly confidential. Address Box 73, c/o The Glass Industry, 55 West 42nd Street, New York 18, N. Y.

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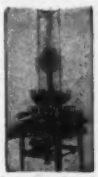

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GLASS EXHIBIT IN NEW YORK

Modern glass from 51 American and European manufacturers, lent by museums, private collectors and the industry, is being exhibited at The Cooper Union Museum for the Arts of Decoration in New York City. The exhibition is entitled "2500°F: The Art and Technique of Modern Glass," and will continue until March 20.

An introductory portion of the exhibition will include a technical and industrial exhibition of glass and glass making. A professional glass blower was on hand at the opening of the exhibition to demonstrate the tools of his trade, and gallery talks by Museum experts will be given and motion pictures of glass making in England, France and America will be shown four days a week.

BROWN INSTRUMENT EXPANDS ACTIVITIES

The Brown Instrument Company has expanded its sales and service activities in the Rocky Mountain area by establishing permanent sales and service representation at 400 Broadway, Denver, Colorado, and 437 Atlas Building, 36½ West Second South, Salt Lake City, Utah.

The company feels that the Rocky Mountain area will become increasingly important in oil refining, steel and copper processing, processing and packing of foods, and in the chemical fields, including the extraction of basic chemicals from Salt Lake deposits.

Donald Larcen has been placed in charge of Denver industrial sales and George Winslow will handle similar duties in Salt Lake City.

DR. McCAULEY RETIRES FROM CORNING

Dr. George V. McCauley, Corning Glass Works physicist who supervised casting of the record 200-inch mirror for the Mt. Palomar, California, Observatory, has announced his retirement from the company.

Dr. McCauley began his career with Corning in 1918 following a year's war-time duty with the U. S. Bureau of Standards. A graduate of Northwestern University, he subsequently earned his doctorate at the University of Wisconsin. In 1912, Dr. McCauley returned to Northwestern to serve on the faculty of that institution for five years.

During a distinguished career as a member of Corning's research staff, Dr. McCauley's outstanding achievement was his work on the basic component of California Institute of Technology's Mt. Palomar telescope, the world's largest. When the telescope is placed in operation shortly, the disk will serve as a light-gathering reflector in enabling man to visually penetrate the universe farther than ever before.

DU PONT STOCK REPORT

E. I. du Pont de Nemours & Co., Inc., was owned by 97,135 separate stockholders as of December 31, 1947, an increase of 5,341 from the number recorded at the close of 1946.

There were 73,963 holders of common stock, and 23,172 holders of preferred stock as 1947 ended. These figures include 5,934 holders of more than one kind of stock.

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